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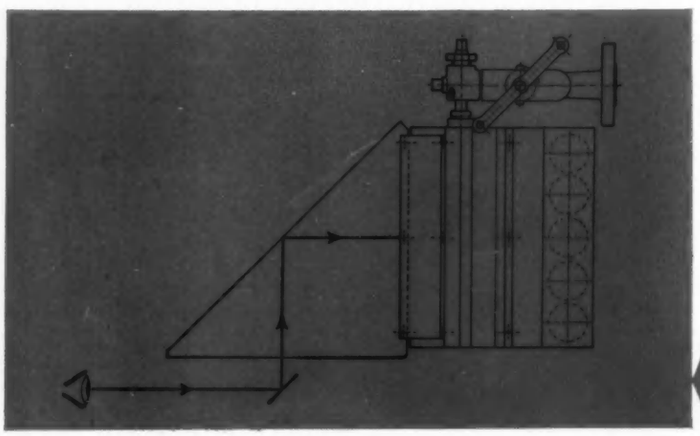

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THE ENGINEER

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No. 5497 **JUNE 2, 1961** VOL. 211

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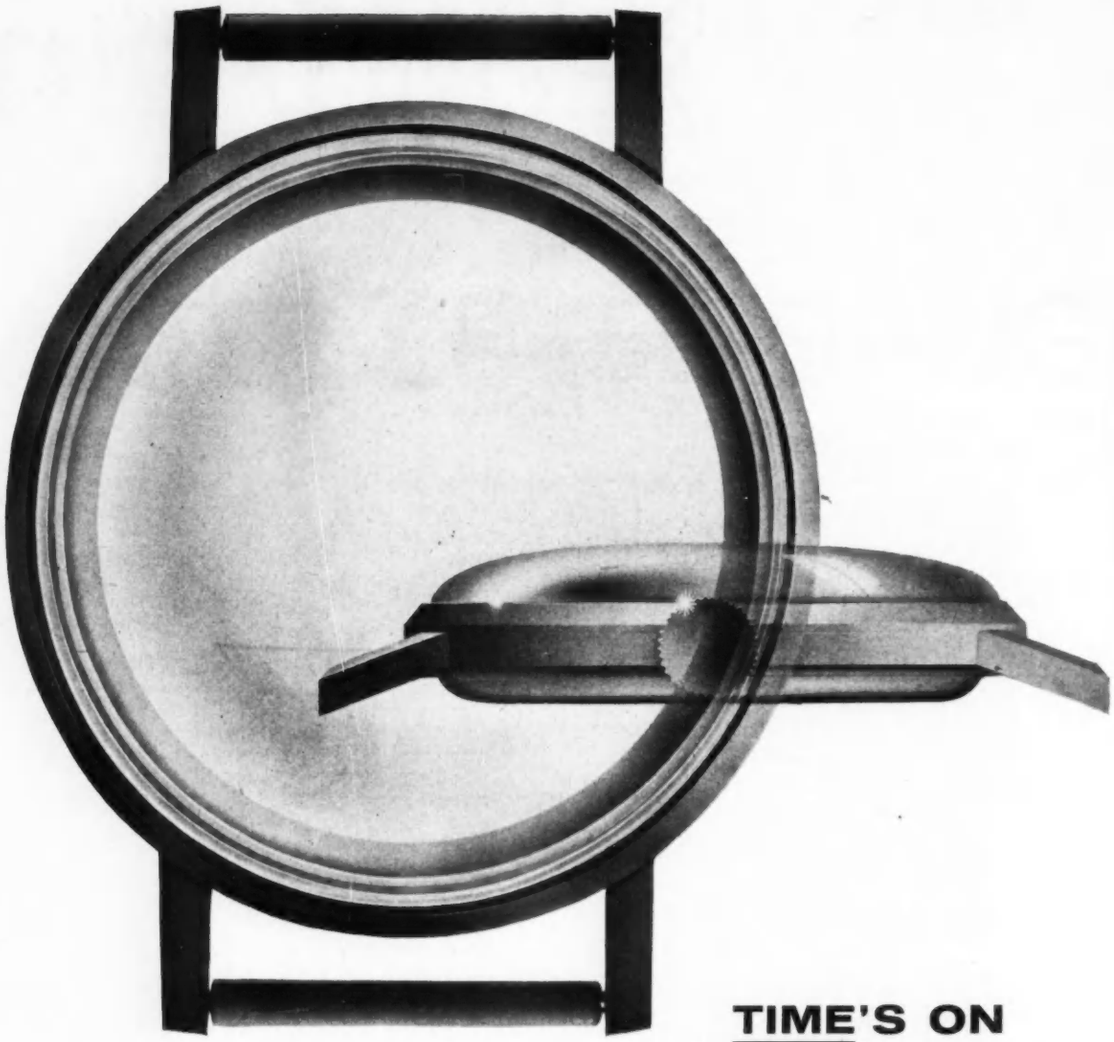

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THE ENGINEER

No. 5497 JUNE 2, 1961 Vol. 211

ELECTRICITY SUPPLY SECURITY

The committee of inquiry set up by the Central Electricity Generating Board has determined the immediate cause of the interruption to electricity supplies in south and south-east England on the evening of May 15. As explained in the Board's statement, reproduced on page 914 of this issue, the interruption was initiated by the operation, on overload, of a protective switch associated with a reactor at Wimbledon. With the loss of this circuit feeding part of the south-eastern area *via* Beddington, the load that it had been carrying was superimposed on that being handled by the four other circuits still in service and supplying the south-east. These circuits then tripped on overload and left a section of the 132 kV grid, linking the power stations and bulk supply points in south-east England, completely isolated from the rest of the 132 kV grid and the 275 kV supergrid systems. In isolation this area was left with a deficit of about 250 MW between the prevailing demand and the available plant capacity. As the frequency continued to fall the power stations in the area shut down, one by one, under automatic or manual controls.

That, briefly, was the sequence of events. But the consumer rightly wants to know not only what went wrong, but why, and whether it is likely to happen again. Unfortunately there is not very much reassurance to be derived from the findings of the committee of inquiry. The first point, emphasised very forcibly by the committee, is that the area affected by the shut-down need not have been isolated from the rest of the country's interconnected system if the Board had been allowed to press on with its plans for extending the 275 kV supergrid. A clear and, as it turned out, prophetic warning, about the consequences of prolonged delays in obtaining consents for transmission lines, was given by the Board's chairman, Sir Christopher Hinton, at a press conference in September 1959. Pointing out that certain transmission lines had not been approved, after negotiations lasting two or three years, Sir Christopher said: "unless we get clearance for those lines reasonably quickly, electricity supplies to east Kent during the winter after next is going to be most gravely imperilled . . ." The fact that the recent supply failure occurred outside the winter months does not invalidate the principle behind the warning. The Board is responsible for operating an interconnected system — probably the largest and most complicated of its kind in the world — and any missing links in the system impose a severe operational handicap.

But it will be argued that while the Board is faced with such handicaps it must operate the system as it is. This leads to the second main point made by the committee of inquiry, which is that during the recent interruption of supply "some errors of judgment occurred." Allowing that occasional errors of judgment are inevitable the unfortunate fact is that, until the required strengthening of the transmission system is effected, the stability of parts of the system will remain so delicately balanced as to leave very little margin for error. In the meantime the committee makes several recommendations (detailed on page 914) to improve security of supply. For example, a study group should be formed to examine the present and immediate future characteristics of the C.E.G.B. network and to identify points susceptible to conditions similar to those in the Thames South control area. There should be a search for better methods of indicating to Grid control engineers the existence of potentially dangerous conditions on the supply system. Present practice should be reviewed to ensure that equipment can be used to its maximum rating without risk of premature operation of protective gear or damage to plant. More specifically, detailed studies should be made to help Thames South control staff to operate at higher levels of system security and to accept the corollary of higher operating costs. Some of these recommendations may well lead to refinements in system operation which will be of long term benefit. In the meantime it is distressing to see the Board forced to run a well planned integrated system "on a shoestring" and we hope that recent events will influence public opinion towards accepting a greater sense of urgency in the public inquiries that inevitably accompany the planning of new transmission lines. Alternatively the consumer will have to accept the fact that any avoidable delays in sanctioning these works may prove to be an expensive luxury.

TUBE TRAIN FIRE REPORT

In his report* on the electrical fire which occurred in a Central Line tube train of London Transport between Redbridge and Gants Hill stations on August 11, 1960, Colonel D. McMullen says: "the accident should not have occurred, and would not have occurred if the lessons of the previous similar case at Holland Park in 1958 had been learnt and applied by certain members of the staff". The fire began with arcing in a power receptacle on the leading motor coach of an eastbound train. Boxes of this kind are used to enable a power cable to be coupled to a train in depot sheds where there are no current rails. By this means trains can be "railed", or moved into a position where their shoes are in contact with the normal live rail supply. Since the box in the train concerned was connected to terminals on the main switchboard which are common with the leads from the positive and negative shoes, the box terminals themselves were alive while the train was in service. These Central Line trains were built in the 1920s, and immediately before the war did not rank as high for replacement as some on other tube lines. Stock built in 1959 and subsequently is now being allotted in growing numbers to this section of the London Transport railways. Of fifty passengers in the train, thirty-nine, together with the

*Report on the Electrical Fire which occurred on 11th August, 1960, between Redbridge and Gants Hill on the Central Line, London Transport Railways. H.M.S.O. Price 3s.

driver and guard, were treated in hospital for the effects of fumes and smoke.

It was shown at the inquiry that the power receptacle box in the train concerned had been damaged in the depot the day before the accident, and although the terminals were changed, the proper tests were not made, neither was the car stopped for changing the box. Responsibility for the accident is held to rest with the depot foreman. His concern had been primarily with the arcing and fire in the depot jumper cable which accompanied the damage to the box, for this could have delayed getting trains out of the depot and affected passenger service. His fault was therefore one rather of error of judgment than neglect of duty. The inspecting officer thinks that the instructions regarding receptacle boxes which had been given after the Holland Park accident had not been sufficiently impressed on him. A reading of the evidence of those responsible for doing so suggests some weakness in communication or supervision. The steps taken at higher level seem to have been adequate, including meetings between the Chief Mechanical Engineer (Railways) and engineering administrative staff, and the showing of an instructional film at all depots. No doubt the lessons both of this occurrence and of the accident at Holland Park will be examined to devise the most effective manner of ensuring that they are not only brought to the notice of all concerned, but embodied in their normal routines.

ON THE SALFORD CAT

On Wednesday of last week Her Majesty the Queen, accompanied by the Duke of Edinburgh, opened new buildings at the Royal Technical College, Salford; and the College acquired the new name, Royal College of Advanced Technology, Salford. Salford was one of the colleges assigned the status of a CAT in 1956. All technological and scientific departments of the College now prepare students for the Dip. Tech. and this award has replaced the external degree of the University of London for students of engineering. Courses leading to the Dip. Tech. are available in aeronautical, chemical, electrical, civil and mechanical engineering and also in applied mathematics, applied chemistry and applied physics. In addition the College offers a growing number of post-graduate courses. Since it was given CAT status the College has undertaken substantially more research than before, it is now equipped in much the way one would expect it to be and there is therefore no need to attempt to draw attention here to any special features. However those concerned were able to show to Prince Philip with some pride a particular piece of research now going on, which he must have found especially interesting. Some of the staff of the College, like Prince Philip himself, are interested in yachting; so, it was found, was one of the final year students. A project was formulated to study the aerodynamic characteristics of yacht sails in a wind tunnel in the Aerodynamics laboratory. Who knows? The research may eventually help this country to win back the Americas Cup. The project has attracted a research grant from the D.S.I.R. So incidentally has a project for research into the vibration of machine tools.

One of the conditions of the National Council for Technological Awards in approving courses is that liberal studies of some kind shall form a part of them; and a good deal of thought is obviously being given to their content. In the limited time available an attempt is made to improve students' use of English in speech, in report writing and in logical thinking, to give them some insight into the relations beween industry and departments of State and to introduce them to the modern social, behavioural and industrial sciences. Experiments are being made with discussion courses on such subjects as "Man in Society" and "Trades Unionism." A number of optional cultural courses are available in, for example, music, archeology and philosophy. In addition it is planned soon to open halls of residence and thereby to stimulate students to develop a corporate social and cultural life of their own. We get the impression that the College is moving with a refreshingly experimental approach towards the initiation of a new form of technological education. We particularly welcome the close contacts it is building up with local industry. It appoints, for example, Associate Lecturers; these are men from industry who become associated with the College on some regular basis as, for example, one day per week and work as members of the staff on that day. Additionally members of the College staff are encouraged regularly to spend time in industry and they are also encouraged to take up consultancies with industrial undertakings. The general criticism has been frequently made recently that Dip. Tech. courses are being too closely modelled on university courses. It is, we suggest, only through the close association of the colleges concerned with industry, as is the case at Salford, that new forms of courses can be developed satisfactorily, so that it will become recognised that a diplomate has valuable qualities different from those of a graduate. Dare we also suggest, having in mind the series of three articles under the heading "Science and Design in Engineering Education and Practice", the second of which is printed in this issue, that CATS should lay more stress in their engineering courses on creative design and less on analysis than the universities do? The close contacts of both the staff of such colleges and their students with industry should make it easier for them to do so than it is for the universities which have been in the past, and ought perhaps to remain in the future, the home of those who enjoy cold and critical analysis and the detection of error, rather than the domain of those who relish the enthusiastic and sometimes apparently rash creation of new ideas to solve new problems which has always been essential in advancing the art of engineering design.

"DRINKA PINTA MILKA DAY" FOR TECHNICAL TRAINING WEEK

On Monday there opened at the Royal Exchange in the City of London in connection with the Commonwealth Technical Training Week an Exhibition of Technical Training. It is a very small exhibition. On the same day in the forecourt in front of the Royal Exchange there opened an even smaller exhibition in connection with National Dairy Week. It is the latter which steals the limelight! The earnest visitor seeking the Exhibition of Technical Training finds himself exhorted not to study his career, but to "Drinka Pinta Milka Day." He sees before him as he approaches the Royal Exchange stands representative of a dairy shop of one hundred years ago, of modern shops, and of modern methods of selling milk. To recover interest in his career he must avoid the crowds of city dwellers who queue up to see a veritable cow and her calf and who, goggling, and perhaps for the first time in their urban lives, are actually able twice (or is it in this instance, thrice?) a day to see a cow milked! He must pass as it were backstage to find the entrance to the Royal Exchange. Nor, even then, so modest is the outward show, will he be sure he is headed rightly till he glimpses through the portals the stand of the City and Guilds of London

Institute, the body responsible for the general handling of the Week throughout the country.

Within the relatively tiny space available the Exhibition is very well done and very effective. The London firm, Technical Designs, was responsible for the general conception. Centrally, facing the entrance door there

is the Institute's stand as illustrated. Stretching out behind it there is a row of double-sided showcases containing a display of exhibits from many of the Livery Companies of the City. On each side there is a row of single-sided stands. On the back wall of each of these stands there is a suitable mural and in front there are models, and display panels for photographs, drawings and diagrams and so forth. Amongst stands of interest to young people are those organised and staffed by the Council of Ironfoundry Associations, the Aluminium Development Association, and the Copper Development Association, the British Transport Commission, the Gas Council, The Civil Service, the Heating and Ventilating Industry, The British Oxygen Company, the British Petroleum group, jointly by A.E.I., English Electric, G.E.C. and Mullard Ltd, the Post Office, The British Iron and Steel Federation, The Federation of Civil Engineering Contractors, The Institutions of Civil, Mechanical and Electrical Engineers jointly, the National Coal Board and the Electricty Council. Soon after the Exhibition opened we were glad to see that many schoolboys were present and were closely questioning the staffs on the various stands. If business continues as brisk throughout the week during which the Exhibition is open it will certainly have done good.

RETIREMENT OF A SECRETARY

Mr. Brian Robbins, Secretary of the Institution of Mechanical Engineers, has just retired. No doubt a lot of other people occupying positions of at least equal responsibility have also recently retired; but none we think occupying so prominent, and indeed so public a position in mechanical engineering. For since the war the duties of the Secretary have been very much enlarged just because the Institution itself has become more active. Many men now only middle-aged can remember the time when, from outside at least, the secretaryship of a major institution looked quite a nice "cushy" job. How different was Robbins's experience! He took over from a very prominent engineer with a strong personality, the late Sir Henry Guy, at a time when there was dissension amongst the members, when, notwithstanding that dissension, membership was rapidly rising, when cooperation between the three major engineering institutions was growing, and when there was growing cooperation also with engineering societies in Europe, in the Commonwealth and indeed the world over. He had to become known to and to know all the more prominent mechanical engineers here and many of those abroad too. Additionally re-organisation of divisions and groups within the Institution became essential, the number of conferences, symposia and ordinary meetings to be arranged multiplied, revision of the by-laws became desirable, and there was much work to be done in connection with an attempt to get rating relief and latterly in connection with the expansion of headquarters into an adjoining property. We do not know, we cannot know, how much the weight of work has been an influence in deciding Robbins to retire before the normal retiring age was reached. Certainly there is no sign whatever that repeated trips abroad on the Institution's business, much social activity, in which his wife so greatly assisted him, and the constant and sometimes nagging work of conferences and committees, over and above the job of administering a much enlarged staff, has in the least undermined what appears to be his present robust health. But he may well have had it in mind that his predecessor retired because of ill-health, very probably brought on by overwork during the war and worry after it. All who ever met Robbins will want to wish him well in his retirement and to wish Mrs. Robbins well too. The good wishes of members will also be extended to Mr. K. H. Platt who succeeds to the secretaryship and to Mrs. Platt who will be able to do so much socially to help him.

The Engineer—100 Years Ago (MAY 31, 1861)

"LOW PRESSURE NON-CONDENSING ENGINES."

"We should not care to risk an estimate of the number of non-condensing engines at work in the kingdom, at pressures intermediate between 20 lb and 30 lb per square inch. We fully believe, however, that, had these consumptive creatures been counted in the census, their number would have taken everybody by surprise. In the mining districts they form a numerous community, the afflicting asthmatic wheeze of the individual members—as they cough their weak but vital steam away in the murky air—accumulating in a roar of pulmonary protest against the engineering folly of the low pressure non-condensing practice. With only 25 lb pressure per square inch on one side of the piston above that of the atmosphere on the other, three-eighths of the steam are thrown away. For the real or total pressure of the steam which marks 25 lb on the gauge is nearly 40 lb, 15 of which go, at every stroke, to expel the air behind the piston; whereas, with condensation, this air would never have found its way in. To extend this view of the case, let it be borne in mind that steam of atmospheric pressure, admitted to a non-condensing engine, would impart no motion whatever. And if the engine were set in motion by independent means, and this foggy feebleness then sent into the cylinder, the result would be a dead loss of all the steam so admitted, and which, notwithstanding its helplessness, would have cost as much in its birth and nursing as the same weight of vigorous vapour, at a pressure of a dozen atmospheres. With condensation, steam of even less than atmospheric pressure could be worked with a very fair rate of economy."

Science and Design in Engineering Education and Practice—No. II

THE BORDERLAND BETWEEN SCIENCE AND ENGINEERING

By HUGH CLAUSEN

It is no doubt an indication of the keen interest being currently shown in the relationships between science and engineering design and research, &c., that we have independently received recently three articles on facets of the subject from three different countries, one from Mr. Hugh Clausen in this country, one from Professor Leyer, of the Swiss Federal Polytechnic at Zurich, and one from Professor Francis, of the University of Melbourne in Australia. All are critical of the education which engineers receive because of the stress it lays upon analysis rather than upon creativeness. This second article is based on a lecture given by the author at the Tube Investments Research Laboratories in November, 1959. Its subject is in reality "design." The author considers that whereas research workers and scientists have a high status in this country, designers have not, and that this neglect of design is having serious repercussions on the ability of firms here to compete with firms abroad in countries yielding greater esteem to designers.

I MAKE NO claim to be a scientist ; most of my working life has been—and still is—spent in that borderland where science and engineering overlap, working on the engineering side of it. Throughout most of it I have been puzzled by differences of outlook and attitude of mind towards the common problem by those on the different side of that borderland. I may be wrong, but it has often seemed to me that the engineer has a better appreciation of the part that the scientist can play in the solution of their joint problem than vice versa. Improvement would result from a better appreciation and understanding —on both sides—of two different approaches to the same end.

I want to see where the difference comes in between the engineering and the scientific outlook—the essential difference—if there is really anything more than an artificial and rather false division between what is called science, or research, and what is called technology. When I speak of science I mean the physical sciences. There used to be a clear distinction between these and the biological or the physiological sciences. Although the distinction is now not always clear, there is a wide region where science and engineering overlap in which the biological sciences can safely be left out of the picture.

The word "Engineer" means different things to different people, from the creator of the Forth Bridge to the man who adjusts an electric bell. Presumably as a start in trying to clear this confusion the engineering institutions have agreed on definitions of a Professional Engineer, and an Engineering Technician, and have boldly published them. They altogether lack the simple dignity of Thomas Tredgold's famous words describing engineering as : "The art of directing the great sources of power in Nature for the use and convenience of man." It would, in fact, be difficult to find a more glaring instance of Victorian snobbery at its very worst! There you see THE ENGINEER, right up in the clouds, standing on his dignity, giving an occasional supercilious glance down at the technician, who is doing his work for him ! It really will not do. We are too late in the field to impose legal restrictions on the use of the word "engineer" or equivalent without specific qualifications, as some countries have done ; but this definition is just not good enough. It practically excludes real leadership which, in any engineering work, involves not so much telling people what to do, as showing, both by precept and example, how to do it. We now have our training courses for engineers and ditto for technicians ; and the latter word has come to have a rather derogatory shade of meaning. It is as well to realise that no man can be an engineer unless he is also by training or by native ability, a technician. The greater includes the less.

HISTORY

The eighteenth century is a good field for studying the relationships between science and engineering. On the one hand there were the astronomers, microscopists, and scientists whose work was only made possible by the instrument makers of the time. These men, of whom Dollond, George Adams, Jesse Ramsden, and Edward Troughton are examples, had something much more than skilled craftsmanship. They were masters of scientific design, and they put us in the lead in the whole world. Ramsden's dividing engine made possible theodolites accurate enough for the work of the Ordnance Survey (but the first really accurate chronometer was not made in this group, but by Harrison, a carpenter !). How much, if anything did these men owe to contemporary science ? What were the relations between them and their contemporary engineers, James Watt, John Smeaton, Bramah, Stephenson, and others ? Did they link up and learn from one another ? Or was the medium in which each was working so different that each could learn little from the others ?

Why was the world lead which we had acquired in the eighteenth and early nineteenth centuries lost later on, when scientific advances should have helped us to retain it ? Was it because the scientists were getting too theoretical and leaving the technology to be carried on at a lower intellectual level ? This has always puzzled me in my wanderings to and fro in this borderland. Coming to more modern times, how much does machine tool design, the basis of all our physical achievements, owe to science? Very little, if anything. There is not, and never has been, a chair of machine tool engineering though a readership has just been created in Manchester. I think Sir Joseph Whitworth must have turned in his grave to see how badly we followed his educational example.

I think it was just after the end of the eighteenth century that the Royal Society fell into the doldrums, and lost touch with reality. On its revival, spurred into activity by the creation of other bodies to make up for its lapses (R.S.A., Royal Inst., Brit. Assn.), it seems to have taken the turning which has since bedevilled most of our national activities, neglecting technology, and leaving it to be dealt with by "lesser breeds." Oddly enough, most of these other bodies have tended to go the same way !

One of my later chiefs, W. R. Cook, now Sir William, told me that he could see no difference between scientists and engineers. I think his eyesight must have been defective. There is a difference, largely in terms of thought. It is difficult to define, and perhaps we can get some help in the discussion. The scientist seems to be mainly concerned with the theory, the principles, leaving the embodiment of these principles to others. He does not, as a rule, care to venture beyond the verbal or the symbolic. The engineer is equally aware of the importance of the principles ; his main concern is to see that they are embodied in the design before the hardware is made. The verbal and the symbolic are his raw materials.

In many fields engineering has made remarkable progress without much help from science. In other fields, particularly in electric, electronic, and atomic matters, no progress could have been made without the help of science. The science and the art are mutually supporting, and progress demands the full development of both, at an equal level of human and intellectual ability. One of the things that always crops up when browsing on these matters is that though the two aspects—the scientific and the technical—demand equal levels of human ability and thought, they do not usually get it. We are now on rather tricky ground, but I have been in it so long that I can speak freely without being suspected of trying to make a case, or indulging in propaganda.

We, as a nation, have suffered much (and still suffer) from serious cleavages of thought. An older one is practically contained in the scholastic phrase—"The Modern Side": The arts, the classics, and the humanities on the one side as opposed to the sciences and technologies on the other—just as if the two were in any way incompatible ! This cleavage, which still bids fair to cripple the nation is, they say, slowly healing, though it and its destructive effects will be with us for a long time yet I fear. The other is a more recent one with "Science" as the dominating note on the one hand and "Technology" on the other.

In the Government establishments where I spent most of my working life the same problems cropped up. Even now in the Scientific Civil Service the relationships are not at all clear. When the Royal Naval Scientific Service was formed, and I was dragged unwillingly out of the "Technical Pool" into it, I had to come into it in a scientific category, as there was not a rank in it on the technical or engineering side equivalent to the post of Chief Technical Adviser that I had been holding for many years before. My work was mainly concerned with engineering design. Now a scientific (or even an experimental) officer is not supposed to do any work with a drawing board, though he is supposed to direct and control the work of those who do use it ! Could official folly go further ?

The late Sir Henry Tizard, opening the Brighton meeting of the British Association

for the Advancement of Science about eleven years ago, said that more scientific research was not needed so much as more ability to apply, in practice, the results of present and past research. Later on in the same year he said at another meeting : " Science may make many things possible, but it does not necessarily make them happen." It is unfortunate that in this cleavage between science and technology it is usually assumed that scientific activities are in some way superior, so men of ambition and ability rarely go in for " Technical " activities. Science has, in fact, attracted the more adventurous minds. How could it ever have been expected that effective advances could be made on the scientific side without a corresponding rise in the level of the engineering side—on which its fulfilment entirely depends ? It is very difficult to understand.

I have been told that men of real talent and ability naturally turn to those activities which can be precisely expressed, presumably in symbolic or mathematical terms. They therefore seem to neglect those matters which cannot be so expressed. What can be more precisely expressed than, say, the cutter spindle and bearing arrangements of a Micron gear hobber ? But how do you express these qualities in symbolic terms ? That little Swiss jig borer in your workshop is a good example of precision of expression of thought. How many of you have ever looked at the detailed sectional general arrangement drawings of such a machine, with a view to studying how such a high accuracy of performance is achieved ? In most cases research only provides the raw material for design. Its results must be digested and processed, and embodied in good design before they can appear in a usable form ; and this engineering work requires an equal intellectual level.

In my forty years or more in this borderland wilderness it has been rare to find a man of real talent on the scientific or research side with any corresponding ability on the engineering design side. Or even to find a scientist who has a clue as to the quality of thought needed to put his ideas into effective practice. I will quote you a case, perhaps an extreme one, and although the man concerned is dead, I had better not mention names. Sir ——— ————, an eminent physicist, Professor of Applied Mechanics at the R.N. College, Greenwich, and adviser on gyroscopic equipment to the Admiralty. Incidentally, his paper on " Armature Reaction in Alternators " in 1906 was the first and best study of what was then a very difficult design problem. I knew him well, though I never worked for him. His principle seemed to be that when he had completed his patent specification, with the usual perfunctory drawings, the job was done. All that was needed was the services of an intelligent draughtsman to . . . draw it out, and the ditto, ditto of an intelligent mechanic to make it and there your are ! He did not seem to realise that of the two aspects of the work, the analytical and scientific research, and the engineering design and manufacture, the second is usually much the more severe problem. If a man has the brain power to do the first part at all he can usually do it without too much difficulty, by himself with a small body of assistants.

Design and Production

When it comes to design and manufacture, hundreds or even thousands of people may be involved in various works and factories, and the sole basis for co-ordination of all these people's work—the one place where price, quality, performance, delivery date, reliability, and all other matters can be properly considered and balanced—is the set of detail drawings as issued for manufacture. It is here that the broadest grasp of the thing as a functional whole is needed, as well as detail consideration of the design (i.e. drawings) of every one of the smallest specialised components. This latter needs an intellectual level at least equal to that at which the analytical and mathematical aspects are considered. Unless this is so ; unless the engineering side of the work is handled by men of the same human calibre as those on the scientific side, the result does not materialise at the same level as the original thought ; and endless delay and expense are involved in repeated modifications.

The matter is not unlike the translation of a book from one language to another. The author may have great intellectual power, the highest ability in exposition, and skilful use of the apt and vivid word. But unless the translator has a corresponding grasp of the subject matter, and corresponding powers of expression in his own langauge, the result will not have the same value as the original. Although the scientist rarely seems to have a real understanding of the engineering design processes, the good designer, even though he may have no formal scientific training, often has a good appreciation of the analytical aspects. He will endeavour to train himself to understand these as far as may be, to a greater extent than the physicist will try to train himself towards some competence in, or appreciation of, the engineering design aspects. This may be merely a reflection of the customary—though quite false—relative esteem in which science and technology are now commonly held. Probably with a better balance in this respect, such as seems to be the case in U.S.A., Germany or Switzerland, for example, our progress would be better, and we should not be so dependent on foreign designs.

Institutions and Design

It has been suggested to me that if the physicist must know all about engineering design to be able to direct and control it he should, logically, also be expected to lead and direct manufacture, in all its multifarious activities and details. This is not so, and the reason is simple. A great wealth of ability, drive, and talent, has been concentrated on production and production methods. Professional institutions and research establishments are founded on, and deal with, this and its related activities. There are a number of good technical journals, dealing both broadly and in great detail with this very thing. If the design has been well done ; if a clear definition exists as to what is to be made ; that is, if a complete set of detailed product drawings is available, so that manufacture can proceed without hesitation or doubt, there is very little difficulty in manufacture, to the precise standard that is expressed in the drawings.

The design stage, in which experimental and research results are processed into a practicable and usable form, has had no such support. Both the professional institutions and the educational establishments seem to neglect it almost completely. There are no good British journals dealing with it. (There are good ones in U.S.A.) The work is, in the main, left to draughtsmen, with little effective help and leadership from those sources whence one might most expect it. The resulting delays and frustrations are not at all surprising. They are inevitable. Adequate attention has not been paid to these matters in the past, and as far as I can see it the situation is getting worse.

The work on these drawings—the complete statement of definition of the product to be—is not a matter of production. It is a matter of design ; the place where quality is injected into the product is on the drawing board, and the instrument used for injecting it is a pencil. Does the scientist hold or guide this pencil? If not, who does?

Few things are more terrifying than the vast clean expanse of a drawing board on which one is starting a design. It is like calling spirits from the vasty deep. Are they there? And will they come? The call must be on just the right note, or nothing happens. And when some senior man comes to see how you are getting on, and you hand him the pencil and say : " Now show me," what is his reaction?

What is Technology?

The word " technology " fitly covers this borderland between science and engineering that we are exploring ; and the dictionary definition of the word is : " Systematic knowledge of the industrial arts." My own personal definition of it, which I prefer, is : " The philosophy of craftmanship." However one defines it, it is always concerned with the making, or doing, of some material thing, rather than the discussion of an idea. Its field is almost infinitely wide, from paleolithic man chipping his stone axe in preglacial times to the design and construction of a modern electronic computer. Instead of technology being regarded as the poor relation of science I like to think of it as described by Sir Eric Ashby in his recent book, *Technology and the Academics*. In this book he shows it to be an activity with a far higher humanistic content than science, being in reality the essential link and meeting point for co-ordination between the arts, the sciences, the humanities, and industry and commerce as well.

Technology, concerned with the making or doing some material thing, immediately involves the definition of that thing—in other words—the DESIGN. This question of engineering design, which has been defined as " spreading brains on the drawing board " is the essence of the whole problem. Whose brains are they? And how do they get there? I have often been called to task for wasting time by insisting on paying too much attention to design detail before making something. But before making anything there must be a clear idea in every detail of what it is that is going to be made. It may be unfortunate, but it is certainly true, and it is likely to remain true for a long time, that the only definition adequate for manufacture is that contained in the working drawings. The best and indeed the only way to achieve success economically in a reasonable time is to see that all the talent, all the vision, and all the drive available are concentrated on the drawing board, even if only one off is being made for trial. Much time—and money—can be saved by application of the Rolls-Royce works and office slogan : " Think before, not after."

Graduates and the Drawing Office

One of the factors causing anxiety for the future is the disinclination—almost amounting to a refusal—on the part of the graduate engineer to work in a drawing-office. By so doing he cuts himself off from one of the most important sources of learning his own profession ; that progression from ideas to ironmongery on which all else depends. If this tendency persists, so that the draughtsmen of to-morrow are only being taught by those of to-day our increasing dependence on manufacturing under licence to foreign

designs is understandable ; and the future outlook is indeed grim. It is customary, in some other countries, for the graduate engineer—whatever his ultimate specialisation—to spend a year or two in a drawing-office, if only in order to learn the rudiments of his own profession. This also in addition to a much more thorough grounding in engineering drawing and design than he gets here during his studies. That beloved slogan of the educationalists: " A sound grasp of the basic principles " is not of much value unless combined with a real ability to apply them in practice.

In an article in THE ENGINEER I wrote : " A reason for the disinclination of the graduate type of engineer to work in a drawing-office may be that this work involves a precision of thought, and a clarity of expression to which he is not accustomed." Objection may be taken to this, but it is true. We have not one unique solution which can be reached by a logical process of thought, but one of an almost infinite number of solutions in detail, each of which might be as good as any other. In spite of this we need a clear, precise, and absolutely definite decision as to the size, shape, material, method of manufacture, treatment, tolerances on dimensions, &c., of—probably —several hundred components involving several thousand separate dimensions, even in the case of quite a small job. An error or discrepancy in one of these dimensions might spoil the performance of the whole system.

In service establishments, and presumably others as well, the phrase : " Research and development work," often contracted to " R and D," is usual. Most of us have a broad idea of what is involved here, but on asking for a more precise definition of the real nature of the work one rarely meets with a satisfactory answer. In point of fact, its most important component, in its effects on the cost, time, and effectiveness of any development is just DESIGN of the material or processes involved. The more effective thought put into the design stage, the quicker is a satisfactory result likely to be achieved. R and D work falls into two classes, the synthetic work of designing material for trial and experiment, and the carrying out and planning of the experiments, analysing the results, and making the deductions from them which are going to lead to further design work.

You may think that I have exaggerated the importance of design and of what I have called, for lack of a better name, " the drawing-office." The customary formal D.O. organisation of an engineering works is not necessary at all in an experimental or research establishment. What is vitally necessary, if uncountable wasted time is to be avoided, is someone, and somewhere, where the precise, complete, statement of exactly what is going to be made can be dealt with and produced before starting to make it. This work may be done by scientists, or by laboratory mechanics (who will subsequently make the stuff) working in conjunction with them. The highly skilled instrument maker, the man of the type I have referred to before, is a rare bird these days. Those of the eighteenth and early nineteenth century combined the functions of both scientist and mechanic. They needed no drawings, other than the sketches they made themselves as they went along, but few scientists can do this nowadays in gear of any complexity. I suppose one of the last was the late S. G. Brown, who started as Professor Perry's laboratory mechanic. He designed and built the Brown Gyro compass, and, though without any formal scientific qualifications, was elected a fellow of the Royal Society. Few men of this type can be found nowadays to work as laboratory mechanics. They are worth more than that, and they know it. The point that I am trying to make is that the design and making of the scientist's experimental material (the art) often needs to be done at an intellectual level at least equal to that of the scientist. If he is unable to do the design work himself he must not expect men working at a lower level to make good his deficiences.

Design in the Drawing-Office

To the scientist, a drawing-office is often merely an ancillary activity to the workshop and laboratory ; the important thing is the experimental work carried out, and the results achieved. To the engineer, however, the drawing-office is often the vital creative centre, the place where the research work is done. When designing new material it is often necessary to carry out, to quite a high degree of detail completion, alternative designs for consideration. Such appraisal will depend largely on detail. This is often better, and cheaper, than making one for trial and then altering it. The experienced engineer, studying these drawings, can see which parts need experimental verification and should therefore be made for trial.

Research and Design

In research or experimental establishments the display of a principle often dominates over its practical application. A very important factor—often neglected—is that unless the experimental gear is in the form of a final production model (or as near as makes no difference) trial results on it may not be representative, so that when a final design is to be made the experimental work has to start all over again. Experimental work should never go further than is needed to establish a principle. On the first suggestion of applying it the design of a production model should be taken in hand, to study its practical application.

One of the most successful experimental groups I ever came across had no scientific or laboratory staff at all, as such. They all had drawing boards alongside their desks, and worked on them, designing gear for trial, and putting everything they had into their designs. On completion of the design they supervised manufacture and erection, and moved into the test laboratory to do the trials and experiments. That critical matter in all engineering work, the feed back from shops and trials to drawing board, was as nearly perfect as could be humanly expected, and progress was rapid. The organisation which this suggested—a number of design groups, with a common services analytical, mathematical, and physicist group to support them—nearly materialised. I think it might have done, but this did not agree with Scientific Civil Service policy. In some branches of work the principle would have advantages.

I often feel myself to be a voice crying in the wilderness. If this talk has stimulated some of you not to be content with the science only, but to pursue the art as well, it will not have been wasted.

Berkeley Nuclear Laboratories

The Central Electricity Generating Board's Berkeley Nuclear Laboratories, which were opened this week by Lord Fleck, are designed to do most of the research and development work associated with the Board's nuclear power station programme. Initially the work of the laboratories will be related to the gas-cooled graphite-moderated reactor fuelled with natural uranium. Therefore it is convenient for the laboratories to be sited next to one of the first two nuclear power stations to be commissioned by the Board. However the laboratories, as a branch of the C.E.G.B. research and development department, are administratively independent of Berkeley power station. A brief description of the laboratories and their functions is given below.

TO carry out research and development work in support of its nuclear power programme The Central Electricity Generating Board has set up the Berkeley Nuclear Laboratories. Their function will be to provide the Board with the specific information it needs to develop nuclear power as an economic, safe and reliable source of electricity supply. In this connection it should be recalled that the Board is already committed to a programme (involving a capital investment of several hundred million pounds) which will make it the owner and operator of the largest aggregation of nuclear power stations in the world.

The Berkeley Nuclear Laboratories are a branch of the Board's research and development department and it was convenient to have them sited near one of the early nuclear power stations since the initial programmes of research work will be closely geared to the natural-uranium, graphite-moderated, gas-cooled reactor. As indicated in our issue of March 3, 1961, page 351 the Berkeley site was chosen because of its proximity to Gloucester and Bristol in an area to which qualified scientific and technical staff might be attracted.

The laboratories are organised in three divisions which deal with materials, physics and engineering respectively. The materials division is mainly concerned with the effects of irradiation upon reactor materials—both structural (mainly steel and graphite) and those used in fuel elements. The physics division will be engaged in studies of the reactor core, firstly on the laboratory scale, using sub-critical exponential assemblies of graphite and fuel elements and, secondly, on the plant scale during the normal commissioning, of the C.E.G.B. nuclear power stations. In nuclear instrumentation, where there is ample scope for the development of improved methods of measurement, the physics division will study, for example, high-energy gamma ray dosimetry and intermediate energy neutron measurements, both of which have an important bearing on nuclear power plants. The physics division is also engaged in an extensive programme of measurements on graphite samples from all the Board's reactors, the aim being to establish the integrity of reactor cores and to ensure maximum life consistent with safety.

Among the matters that will concern the engineering division is the mechanical performance of fuel elements under operating conditions and rigs are being built at Berkeley for studying, under full reactor conditions of

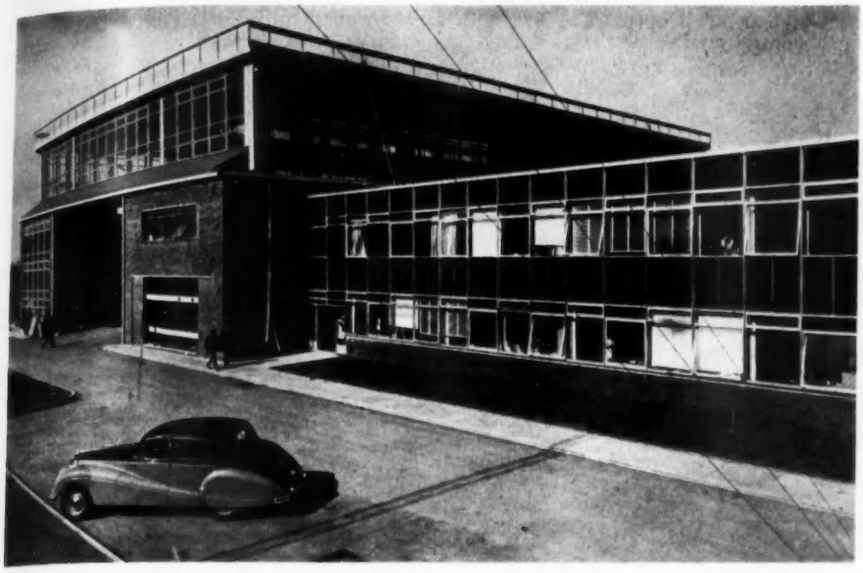


Fig. 1—Engineering wing (left) and part of the administration block (right) of Berkeley Nuclear Laboratories

temperature and pressure, both the heat transfer properties and the mechanical endurance of fuel elements. The mechanical aspects of fuel element handling, control systems and instrumentation will be given detailed attention. One section will deal with pressure circuit components, studying the complex stress systems involved and making the required mechanical tests.

Although the laboratories share a common boundary with the Berkeley nuclear power station, on the banks of the Severn they are administratively independent. In plan form the main laboratory block is E-shaped. On the north side are the shielded area, where radioactive materials are handled, and the laboratory wing. On the south is the engineering hall (Fig. 1) which is linked with the laboratary wing by the administration and office block. The buildings include a boiler house, a maintenance block and a staff canteen. The total floor area of the laboratories is about 100,000 square feet, and the cost, including the initial plant and equipment, was about £2,000,000.

Shielded Area

Normally access to the shielded area and the laboratory is through change rooms in which protective clothing is put on. Before leaving the area members of the staff remove the protective clothing which is then washed in a laundry adjoining the change rooms. To provide the continuous ventilation needed in these radioactive conditions there is an air-conditioning system which supplies warmed fresh air to the buildings and extracts it through filters which remove any radioactivity before discharge into the atmosphere through a 75ft chimney. This ventilation system is designed to maintain a slightly negative pressure inside the radioactive areas so that, in the event of a release of radioactive materials in the buildings, the chances of any escaping into the atmosphere are negligible. All drains from the radioactive areas lead to hold-up tanks where the effluent can effectively be freed from any traces of radioactivity before final discharge.

The shielded area, about 180ft long by 100ft wide, is designed to enable the materials division to undertake post-irradiation examination of fuel elements and test specimens, such as steel, from reactors. Fuel elements are received in transport flasks containing up to 1,000,000 curies of radioactive material. At present fuel elements consist of cylindrical rods of uranium, about 1in in diameter and of various lengths between 12in and 40in, sheathed in magnesium alloy cans having helical fins and longitudinal splitter vanes to improve heat transfer characteristics. After removal from a reactor each complete element is sealed in an outer canister of stainless steel. Up to thirty of these canisters are loaded in a transport flask (about 8ft cube and weighing about 45 tons) of cast steel to provide shielding during transit to the laboratories. There the flask is off-loaded by an overhead crane and lowered to the bottom of a concrete-lined pond, 20ft square, filled with water to a depth of 24ft (Fig. 2). The lid and lifting gear are then removed by the crane.

Subsequent handling operations in the pond are done by a manipulator in the form of a travelling gantry carrying a crab which can be positioned over any part of the pond. The manipulator on the crab is a vertical tube equipped with a grab on the lower end whereby the canisters can be handled, one at a time, either vertically or horizontally. All such operations are manually controlled but a limit switch on the manipulator ensures that active material cannot be lifted dangerously near the surface.

At one edge of the pond bottom is an elevator conveyor which has a power-operated chain drive and is equipped with a "bucket" in which the canisters can be raised and then transported along a horizontal shielded tunnel leading to the working area. This elevator, including the bucket and twin chains is made of stainless steel and the guide rollers are of bronze.

The working area is a rectangular enclosure 30ft long by 8ft 6in deep by 14ft high with concrete walls 5ft thick lined with ½in mild steel. This space is divided into three "caves" (Fig. 3) by two sets of sliding partitions (each 62 tons) and rising partitions (each 10 tons). Three plug doors (each 10 tons) give access through the rear wall of the caves as shown in Fig. 4. All these doors and partitions are power driven. When in position these partitions provide enough shielding between the caves to allow maintenance to be done in one of them while the others remain active. With the partitions withdrawn materials and equipment can be moved from one cave to the other. For transferring small items such as tools, to and from the caves there are circular posting ports which pass through the plug doors (Fig. 4) and are equipped with heavy, rotating shielding shutters.

Observation from the front is through windows formed of lead glass filled with a zinc bromide solution. In addition the first and second caves have Barr and Stroud periscopes for scanning the whole area.

The caves have been designed so that whilst the dose rates in the operating area remain well below permissible levels, any one cave may contain an activity of 50,000 curies with 10,000 curies in each of the other two caves. All operations within the caves are carried out by remote control and each cave has its own manually operated, remotely controlled manipulator. In addition, there is a power driven manipulator which runs on overhead rails and can be used in any of the three caves. This power manipulator can be connected to the emergency electrical system in the event of a main supply failure.

In the first cave the fuel element is removed from its outer can and is inspected visually. First, the transport bottle containing a fuel element is picked up from the bucket of the elevator by the power manipulator and is placed, cap down, in a bottle-opening machine which is bolted to the rear wall of the cave and operated by two handweels at the control face. It carries two pneumatically operated chucks facing each other on a vertical axis : the upper one grips the base of the bottle and the lower grips the cap. Rotation of handwheels outside the cave turns the lower chuck and raises the upper, so that between them they unscrew and withdraw the cap, exposing the fuel element inside.

Each handwheel is mounted on a small gearbox at the end of a shaft passing through the centre of a tubular steel plug with bearings at each end. The plug fits in a steel tube which is cast into the concrete, and extends horizontally from the outer, control,

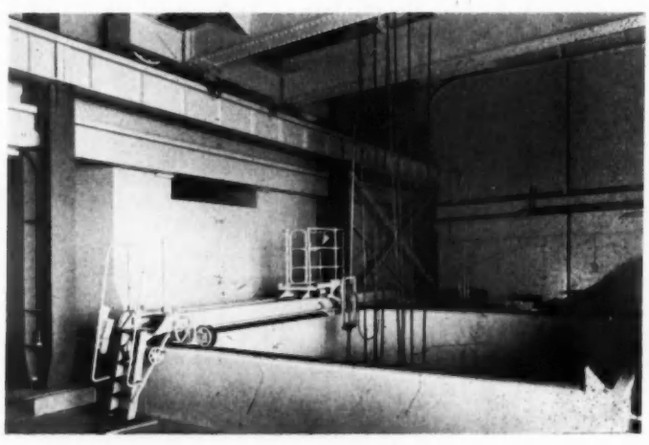


Fig. 2—"Cooling" pond for temporary storage of irradiated fuel elements in shielded flasks under water

face to the inside face of the wall. The shaft and the plug are stepped so that there is no streaming path for radiation. The drive from the in-cave end of the plug is taken across the cave to the machine by a normal shaft with universal couplings at each end. Similar drives are used for all rotary controls, and where appropriate the wheel has a calibrated scale. Some of the in-cave shafts are telescopic, and two of the plugs have auxiliary gear boxes and selector levers, so that either of two shafts can be driven from each wheel.

Normally the fuel element will be a uranium rod encased in a spirally-finned can, and may have transverse bridge pieces and longitudinal struts. The power manipulator extracts the element from the bottle and transfers it across the cave to the end-cap bridging machine. Basically this is a vertical mill with the usual traversing gear, but the head drives a slitting saw which can operate in either of two planes to make longitudinal or transverse cuts. It removes the bridges, struts and end caps, leaving only the cylindrical centre assembly of the element. It can also be used to cut local transverse sections for detailed examination. The feeds are operated by handwheels on the control face of the caves, and the element is held to the table by pneumatic clamps. The machine is power-driven and has its own coolant circulating system, with arrangements for disposal of active swarf.

Usually radiographic examination takes place at this stage, without the obstruction of bridges and struts, the element having been transferred to the radiography machine in the second cave, where as many exposures as may be required can be taken. As the irradiated fuel element itself has a powerful blackening effect on the X-ray film, this machine is designed to transfer the casette as quickly as possible between the shielded position and the exposure position. Operation of the machine is automatic and is governed by an electro-pneumatic system linked to the controls of the X-ray generator. It is estimated that in the worst anticipated case, blackening by radiation will be less than 2 per cent of that by the X-rays. Mechanism is provided to rotate or traverse the element to expose any desired cross-section ; it is operated by handwheels on a control console at the cave face. If necessary the machine can handle complete elements, i.e., with struts, bridges and caps still attached, or any other object which comes within the dimensions of the film. The automatic sequence of transferring the film from the shielded zone to the exposure position and retrieving the exposed film occupies about six seconds. Of this, the exposure time is about one second and is maintained under the control of a circuit which integrates the milliampere-seconds of the discharge until a pre-set value is reached. Allowing for warming up of the generator—about thirty seconds—and inserting and withdrawing the casette, the whole operation occupies two to three minutes, so that the utilisation is virtually governed by the rate of placing and positioning the subject. The X-ray equipment is a Solus-Schall 130kV set. The machine and its auxiliaries are Hobson design and supply. The high-tension cables pass through the rear wall, and inside the cave they are protected from radiation damage by lead and steel screening.

Preparation for final stripping of the can from the element is completed by the three-saw machine in the first cave. The saws are aligned to cut radially to a common centre, and are spaced at 120 deg. Depth of cut is adjusted by a handwheel at the control face which moves the three drive heads in unison. The element is fed vertically downwards through the machine, making three longitudinal cuts through the can material, so that the can may be removed in three pieces. It can accommodate elements that are badly bowed and yet avoid excessive cutting into the fuel rod, and, if need be, it can make single cuts at any desired orientation. The drive and feed motors are completely enclosed in the main casting. Clamping and locking arrangements are electro-pneumatic, and these and the power feed are controlled by a single selector switch and a push button.

The second cave is equipped with a metrology bench capable of measuring any length up to 4ft to an accuracy of 0·001in, diameter or thickness, at any position or orientation to 0·0001in, and extent and location of bow to 0·005in. Viewing during these operations is assisted by the periscope, which can also be used, at ×4 magnification, for close examination of the surface. The diameter and bow measuring heads are mounted on a carriage which is traversed by an external handwheel. Other functions are performed by the manipulator. Newall rollers are used in the length-measuring arrangements.

Machining operations on the fuel rod (or other material) are carried out by a universal milling machine in the third cave. It is similar to the end-cap machine, but has a more complex head with multiple spindles, two speeds, and indexing capabilities. The clamping arrangements are also versatile, and can accommodate pieces of a wide variety of shapes. The machine is capable of sawing, milling, drilling, or other operations requiring rotating tools, and it is used to prepare mechanical-test and other samples of any form that may be required for examination in the cells. Again, traversing is by handwheel, clamping is pneumatic and the power and coolant drives are self-contained.

Transport between the caves is effected by a G.E.C. Mk. I power manipulator which can handle items up to the size of transport bottles and can reach any position in the cave working area. It is carried by a gantry running under the cave roof and is operated from a mobile console in the control area.

Specimens prepared in the third cave are transported by a shielded "railway" to a suite of nine cells arranged at right angles to the caves. Eight of the cells are 5ft wide, 4½ft deep and 6ft high and are separated from each other by fixed concrete partitions 20in thick. The ninth cell is of double width. Shielding at the front of the cells consists of a wall of heavy concrete 2ft thick, 2ft 9in high on which is a lead wall 10in thick with inset lead glass viewing windows. The roof is of steel, 10in thick, pierced to take manipulators and the rear wall is of normal concrete 4ft thick with removable plug doors. The shielding ensures that acceptably low dose rates are received in the operating area when one cell contains 500 curies, with 100 curies in each of the other cells. The railway trolley is driven by a three-phase squirrel-cage motor, with class-H insulation.

Two cells are used for machining operations on test specimens, a third houses an "Instron" tensile testing machine and yet another is employed for metrology. The double cell is for the steel specimen monitoring programme. In another cell there is an encapsulating rig for sealing specimens in silica and several furnaces for subsequent heat treatments. Finally, there are two general purpose cells for short term experiments, and a cell for storage and general decontamination work.

In line with the cells are a number of lead box suites designed for work with specimens whose activity is less than one curie. They are sealed, steel boxes equipped with "Perspex" windows, each surrounded by lead 4in to 10in thick, fitted with flush lead glass windows. Typical uses for lead boxes are metallographic examination and testing and small scale physical chemistry. The lead boxes are contained in cubicles with access from the cell operating area and they are designed for operation from at least two sides whereas the cells can be operated only from the front face.

Behind the cells and lead boxes and the caves are maintenance areas, accessible through an additional change room. A decontamination bay, a maintenance workshop and a first-aid room lead off this area which is also equipped with a special change room for pressurised suit work, should this be required on grossly contaminated items.

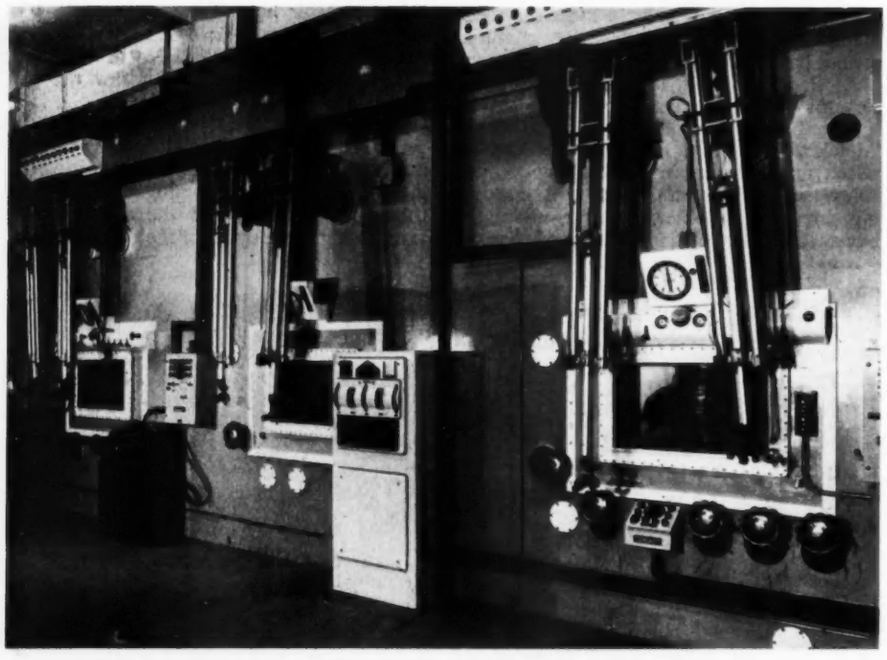


Fig. 3—Operating face of shielded caves in which irradiated fuel elements are stripped and specimens prepared for physical examination and tests

All walls, ceilings and other surfaces are finished with a cold cured epoxy resin paint and in certain areas a " strippable " coat has been added. One ventilation system serves the caves and cells, whilst a separate system serves the operating areas. Before discharge to atmosphere the air passes through several filters—a fireproof filter inside the cave, a flameproof absolute filter immediately outside and a second flameproof absolute filter in the plant room. Similar precautions are taken with the gaseous effluent from the cells, lead boxes and operating areas.

Liquid effluent from the caves, workshop, decontamination centre and pressurised suit change room is regarded as being of medium activity and is treated by flocculation precipitation before being mixed with low activity effluent from all other areas in this wing. Low activity effluent may be treated similarly. The radioactive content of the effluent as discharged from the laboratories will always be negligible.

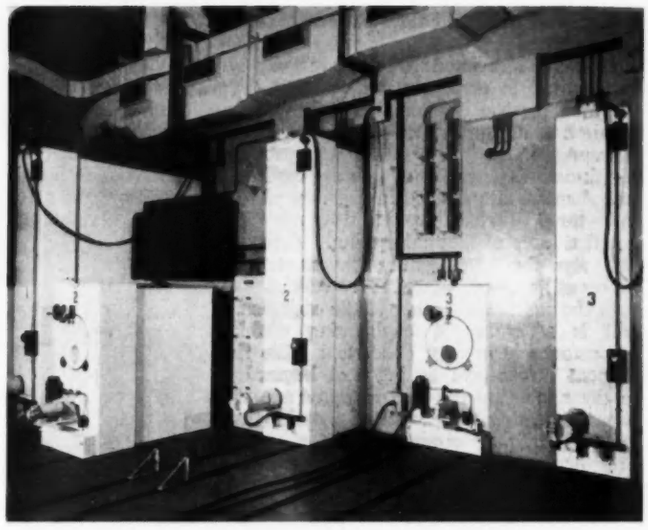


Fig. 4 — Rear view of shield caves showing sliding partitions (No. 1 withdrawn) and plug doors (No. 2 withdrawn to give access to the inside of this cave)

Laboratory Wing

The laboratory wing, at right angles to the shielded area, is a three-storey building providing laboratory accommodation on the ground and second floors, with all services and ventilation ducting on the mezzanine floor. Whilst the shielded area is designed for post-irradiation examinations and is concenred mainly with operational research, the work in the laboratory wing is centred more on the necessary fundamental investigations into the behaviour of reactor materials. This wing serves, mainly, the materials division but it also houses the solid state physics and the graphite sections of the physics division.

On the ground floor there is accommodation for an analytical chemistry laboratory, two general metallurgy laboratories, a " hazard " chemistry laboratory (equipped with its own special change room), laboratories for work in solid state physics and a laboratory shared between health physics and nuclear instrumentation. Finally there is a balance room, a store room and a glass blower's workshop. The second floor houses the graphite laboratory and laboratories for electron microscopy, physical chemistry, X-ray diffraction, metallography, spectrometry and general metallurgy. There are also photographic dark rooms, a dark operations room, a furnace and fabrication facility, a graphite furnace room and a small general workshop, for work which must be carried out within the radioactive areas.

The analytical chemistry equipment has been designed mainly to determine in irradiated fuel the degree of utilisation of fissile materials and the levels of trace impurities. It also provides a general analytical service for the laboratories as a whole. Specimens with a radioactive content of up to one curie can be handled and much of the work is carried out in specially designed fume cupboards. The " hazard " chemistry laboratory, equipped with its separate change room, is designed for physical chemistry research at higher levels of radioactivity and the equipment includes fume cupboards and glove boxes for handling alpha-active materials. In the physical chemistry laboratory an important part of the work is the study of high temperature oxidation of materials such as uranium and magnesium alloys in carbon dioxide atmospheres. An electron diffraction unit, an X-ray micro-probe analyser and a mass spectrometer are provided for use in this work.

In the three general metallurgy laboratories the emphasis is on the metallurgical properties and behaviour of reactor materials. Planned investigations include the growing of single crystals of uranium and associated electron microscopy studies, work on reactor materials using an " Instron " tensile testing machine, the measurement of bowing deformation in uranium under low loads, studies of creep in graphite at low temperatures and of the mechanism of the initiation and development of leak paths in canning materials. Two electron microscopes (one, by Philips, with resolution down to 7 Angstroms) are associated with this work together with ancillary equipment including an evaporator and an ultra microtome. The X-ray laboratory is equipped with an X-ray diffractometer, general apparatus for powder crystallography, a fine focus X-ray set and an electron beam micro-analyser. A metallographic laboratory is equipped to prepare specimens for subsequent examination and photography of microstructure. Arc furnaces, high-frequency furnaces, and general heat-treatment furnaces, together with a rolling mill, a swaging machine and a 50 ton press are installed in the furnace and fabrication room and a special high temperature furnace (operating at temperatures up to 3000 deg. Cent.) is installed in the graphite furnace room.

The graphite laboratory of the physics division provides the necessary service for the Board's reactor graphite monitoring programme and is also concerned with more fundamental studies of the behaviour of graphite under irradiation. In each of the Board's reactors there are several thousand graphite specimens throughout the core which will be removed in accordance with a predetermined programme and measured to determine changes in weight (due to oxidation), physical dimensions (due to Wigner growth), and stored energy. Associated fundamental research is concerned with the properties of irradiated and unirradiated graphite, thermal annealing, stress relaxation and radiation damage.

The remaining laboratory is shared between the health physics group and the nuclear instrumentation section of the physics division. The health phsyics group provides a health physics service to the whole laboratory, including personnel monitoring, supervision of decontamination procedures, measurements of airborne radioactivity, and a consultant service to all staff on precautions when using radioactive materials.

Engineering Hall

The engineering hall forms the southern end of the laboratories and is 160ft long, 115ft wide and 60ft high. It provides accommodation for the main workshops of the establishment, the large rigs of the engineering division and for the numerous laboratories of both the physics and engineering divisions. At present it also houses the main laboratory stores and the stores office.

On the north side of the hall is a gallery, 30ft wide along the whole length of the building. Below the gallery is a carpenter's workshop and store, main mechanical workshops, laboratory stores and stores office. The mechanical workshop is equipped to manufacture all rigs and equipment required in the laboratories.

The gallery houses the major part of the physics division and has laboratories for radioactive counting, reactor physics, health physics and nuclear instrumentation, together with instrument and electronics workshops and a photographic dark room. The radioactive counting laboratory, which is shared by the reactor physics and nuclear instrumentation sections, is equipped with a wide range of counting equipment. In one corner of this laboratory a small area has been partitioned off as an isotope laboratory and fitted with a fume cupboard, where small, unsealed sources of up to one millicurie are handled. The reactor physics laboratory serves the needs of the two exponential assemblies to be erected on the main floor of the engineering hall, the immediate purpose of which is to investigate absorber design and the effect of vacancies in reactor lattices.

The nuclear instrumentation laboratory is chiefly concerned with the development of improved methods of radiation detection. Problems under investigation include the dosimetry of high energy (6 MeV) gamma radiation, fast neutron dosimetry and spectrometry methods, burst cartridge detection and for measurement methods to be used in shielding experiments during the commissioning of the Board's reactors.

The associated small electronics workshop is responsible for local electronics development and for providing a maintenance service for the rest of the laboratories. On the main floor of the engineering hall are two rigs for the investigation of the heat transfer properties of fuel elements. The rigs contain fuel element cans fitted with electrical heaters and they employ atmospheric air as a coolant. A closed circuit, pressurised rig, using carbon dioxide as the coolant is soon to be added for heat transfer studies under reactor conditions, and a rig for endurance tests on fuel elements contains a dummy reactor channel in which complete fuel elements can be tested. There is also a visual flow rig in which water, loaded with a fluorescent dye, is pumped past a fuel element held in a " Perspex " tube to

demonstrate the fluid flow patterns around the element.

Problems associated with end cap welds are investigated in three rigs which have been designed for the measurement of the force required to push off an end cap under a variety of representative temperature and pressure conditions. The effects of thermal cycling in fuel elements are studied in a group of four rigs—three of which provide slow rates and one fast rates of thermal cycling. There are also rigs for investigating the mechanical effects of fin vibration and fuel swelling.

In the south-east corner of the engineering hall is a group of engineering division laboratories primarily concerned with fuel element mechanical testing and inspection. In these laboratories, fuel elements are prepared for testing in rigs, and are examined and inspected at the completion of the tests. The equipment includes plant for welding, pressurising, cleaning and gas filling the test elements. A 150kV X-ray set has been installed for radiographic work and there is an associated dark room. Polishing, etching and microscopic examinations of specimens are carried out in a metallographic laboratory.

An engineering instrumentation laboratory provides a necessary service to the engineering division. It is concerned with the design, calibration and subsequent behaviour of such items as thermocouples and strain gauges and, in particular, with control problems in rigs for the fast thermal cycling of fuel elements. Seal test rigs have been installed to investigate the behaviour of O-rings (static, reciprocating and rotary) and future work will involve a study of fuel handling equipment and the problems associated with charging and discharging a reactor channel. In the various out-of-pile tests on fuel elements all reactor conditions are introduced with the exception of irradiation. Close co-operation with the staff of the shielded area ensures that any unusual condition found in the mechanical properties of irradiated elements, such as buckling or bowing, may be simulated on unirradiated fuel elements and tests carried out to determine whether these conditions affect the performance or behaviour of the elements.

Auxiliary Services

The main adminstration block links the laboratory and engineering wings and provides accommodation for the managerial and administrative staff. In addition there is a drawing office on the ground floor and a conference room and a comprehensively stocked library on the first floor.

The laboratories have an electrically supplied central heating system. The equipment consists of two 11kV, 2MW electrode boilers operated under off-peak load conditions and a 100kW electrode boiler for supplying domestic needs during the summer months. The large boilers heat water which is then stored in three pressurised storage vessels and used to provide central heating for the whole of the laboratories, including heat for the air-conditioning plant. The laboratories are served by an 11kV substation and at present impose a load of about 7MW which may rise ultimately to about 14MW.

A Calor-propane bulk storage tank of 12,500 cubic feet capacity provides the necessary gas supply to the laboratories. There is also a liquid nitrogen plant and an air compressor, whilst a carbon dioxide plant will be installed at a later date. Cooling water for the shielded area and laboratory wing is supplied by an independent closed circuit system of 1000 gallons per hour capacity at a pressure of 100 lb per square inch gauge ; a separate system of 6000 gallons per hour capacity is installed to serve the engineering hall.

The architects for the Berkeley nuclear laboratories were Harry S. Fairhurst and Son. The consulting engineers for the mechanical plant were G. H. Buckle and Partners while the Southern Project Group of the C.E.G.B. acted as consultants for the civil, structural and mechanical work.

The main contractors were as follows : civil engineering, Tersons, Ltd. ; ventilation and heating, G. N. Haden and Sons, Ltd. ; steelwork, Modern Engineering (Bristol), Ltd. ; electrical engineering, N. G. Bailey and Co., Ltd.

For the whole of the shielded area the main contractor was H. M. Hobson, Ltd., Wolverhampton, and this company was responsible for the design and supply of the equipment described.

Laying the Cross-Channel Power Cable

By the end of this year it is expected that the cross-Channel power link between the systems of the Central Electricity Generating Board and Electricité de France will be in operation. The link will allow the transfer in either direction of 160MW. In the following article the characteristics of the British half of the cable and the arrangements in the cable-laying vessel are described.

A VISIT to Dover took place on May 25 to inspect the C.E.G.B. collier, " Dame Caroline Haslett," before the vessel was due to sail to lay the sea portion of the British half of the cross-Channel power link. The French half of the link and the land section of the British half had already been laid. During the visit a film was shown of the sea trials of laying, jointing and testing two lengths of similar cable which were carried out in September, 1958. An account of the work, and of the project as a whole, was given in our September 26, 1958, issue, page 499.

Manufacture of the British cable has been shared between the Woolwich factory of Associated Electrical Industries, Ltd., and the Trafford Park, Manchester, factory of British Insulated Callender's (Submarine) Cables, Ltd. Each company was responsible for producing one 15-mile leg of the submarine cable and one 4-mile leg of the land cable.

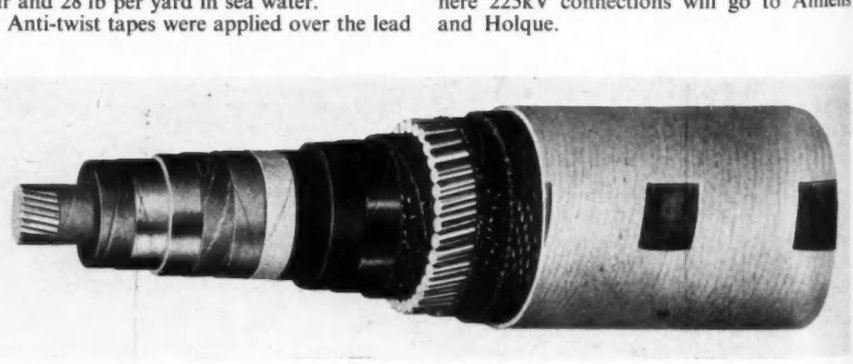
The structure of the cable is illustrated below. Two of these cables are laid side by side, one operating at 100kV positive to earth and the other at 100kV negative, the rating of the link being 160MW at 200kV d.c., 800A. The submarine cable conductor is of 0·525 square inch cross section and consists of stranded copper wire lapped with an electrostatic screen. The solid impregnated paper insulation, also lapped externally with an electrostatic screen, is sheathed with lead alloy-E which is protected against corrosion by vulcanised rubber tapes. Armouring is provided by a single layer of 0·232in galvanised steel wires with appropriate beddings and servings. The cables weigh about 39 lb per yard in air and 28 lb per yard in sea water.

Anti-twist tapes were applied over the lead sheath and under the anti-corrosion protection. These tapes are to ensure that the cable is not damaged under the excessive tensions that may be required to lift the cable out of the sand on the sea bed during recovery after a possible fault. The design stress of these cables is about 150,000V per centimetre at ambient temperatures.

Larger conductor sizes have been used for the land cables, because of the inferior heat dissipating properties of the soil compared with those of the sea. Over sections of the route where normal loam is found a conductor size of 0·6 square inch is employed, but in the shingle areas, which have very poor thermal dissipation properties, an 0·925 square inch conductor is necessary.

The land cable extends from Lydd, where a converter station is being erected, to a link-house at Dungeness, a distance of between 3 and 4 miles. It is similar in design to the submarine cable, except that over the Lydd–Dungeness link-house lengths neither anti-twist tapes nor submarine anti-corrosion protection are used, and the armour wires are considerably smaller in size. The section of land cable from the link-house is joined to the submarine cable below high water mark for thermal reasons, and therefore includes anti-corrosion protection. It has armour wires of the same size.

From Dungeness the British cable extends for 15 miles to the point of connection with the French cable in mid-Channel. Depths vary from 14 to 20 fathoms, and the mid-Channel end of the cable is in 15 fathoms of water. The French sea cable, laid on May 23, runs to Le Portel, a suburb of Boulogne, whence a land cable extends to the converter station at Echinghen. From here 225kV connections will go to Amiens and Holque.



Construction of power cable for the cross-Channel link

Modifications to the "Dame Caroline Haslett," both for the 1958 trials and the present laying operations were carried out for the C.E.G.B. at the A.E.I. Woolwich works. Two holds were adapted for stowing the cable, which was loaded in two 28,000 yard lengths, weighing 1200 tons in all. Fairleads were fitted for loading the cable on to the deck, and "A" frame roller gears were installed on deck to lead the cable to the brake gear on the poop. This gear consists of manually-operated screws with specially-designed shoes to give an even spread of pressure over the cable passing through. A stern sheave (illustrated)

Preparing the stern sheave for fitting to the C.E.G.B. motor collier "Dame Caroline Haslett"

was fitted—a steel fabrication weighing about 6 tons, fitted with a movable self-adjusting central fin for allowing the cable to be aligned against prevailing current conditions during laying. The cables must lie side by side not more than 10ft apart so that the effect of their respective fields will not cause a deviation of more than 2 deg. in the compasses of ships passing over them.

The sheave was calibrated for guidance in operating the brake gear during laying, the point at which the cable leaves the sheave being adjusted according to speed of laying and depth of water so as to maintain the correct tension. Reference was made in our May 19 issue to the solution by computing techniques, at the B.I.C.C. Wood Lane research laboratories, of the equations relating the laying parameters of depth, speed, angle and tension.

The vessel was equipped with a Decca survey track plotter for course guidance during the laying operations. In addition to normal radio communication facilities on m.f. and v.h.f. port control channels, two special v.h.f. channels were provided for communication with the C.E.G.B. and for r/t working during cable laying.

The ship has also been equipped with gear for cable recovery and repair if necessary, including a twin capstan gear comprising a 90 b.h.p. diesel engine driving a horizontal-piston Williams-Janney pump feeding hydraulic power to two oil motors which are connected to the mechanical system of the winch gears. The main winch barrels are of 8ft diameter.

On the British side the Lydd–Canterbury 275kV link is expected to be ready at the end of July, and the complete route should be operational for power transfers in early December after two or three months' trial operation. Exclusive communications channels are available to the C.E.G.B. and Electricité de France for consultations preparatory to importing or exporting power. At a press conference during the visit to Dover it was stated that the characteristics of the British half of the cable would be such as to minimise the effect of transients on the system.

Radio and Electronic Components Show

No. I

The seventeenth exhibition of the Radio and Electronic Component Manufacturers Federation was opened at Olympia, London, on May 30 and closes today June 2, at 6 p.m. A first selection of exhibits is received below.

THE Radio and Electronic Components Show this year is said to be over three times larger than any of its predecessors and is being held at Olympia for the first time. In many directions the exhibition this year emphasises the continually improving standards of reliability achieved in electronic components for aircraft and missile use, and shows how this trend is having its impact on domestic radio and television.

Marconi Instruments, Ltd.

Instruments shown by Marconi Instruments, Ltd., St. Albans, Herts, include a wide-range Wien bridge oscillator TF1370, Fig. 1, covering 10 c/s to 10 Mc/s (sine wave)

Fig. 1—Wide-range Wien bridge oscillator—Marconi Instruments

in six decade bands. Square waves are generated over the range 10 c/s to 100 kc/s. Two cathode followers precede the single amplifying stage and are arranged so that while a very low output impedance for feeding the bridge is achieved, minimum capacitance is presented to the amplifier and maximum bandwidth is obtained. Outputs from 1mV to 3·16V are available via a switched attenuator covering 60dB in 10dB steps. The signal level applied to the input of the attenuator is continuously variable and is monitored by a meter calibrated in open-circuit voltage and decibels. A single tuning scale is used for the four lower bands and separate scales for the two upper bands; this gives a total scale length of 105in and makes a 1 per cent change in frequency easily discernible. The control has a dual ratio of 3 : 1 for rapid adjustment and 18 : 1 for fine tuning. Suitable applications of the instrument as a sine wave oscillator are tests of transmission lines, filters and attenuators, or provision of excitation voltage for a.f. and r.f. bridges. The square wave output is applicable to purposes such as rapid testing of audio amplifier bandwidth.

Among other instruments are a wide-band millivoltmeter (TF1371) covering 30 c/s to 30 Mc/s and having a voltage range of 100μV to 300mV or up to 30V with an additional multiplier. The meter shows the average value of an a.c. waveform and is calibrated in the r.m.s. value of a sine wave. A further scale shows decibels relative to 1mW in 600 ohms. Also shown is the TF1374 precision crystal calibrator for 100 kc/s to 1500 Mc/s, having a stability of one part in 10^6 per month. Check points are provided as zero crystal beats at switch-selected intervals of 10 Mc/s, 2 Mc/s, 500 kc/s or 10 kc/s, free from sub-harmonics, enabling the instrument to be used for purposes such as standardising signal generators and oscillators, or setting up h.f., v.h.f. and u.h.f. transmitter frequencies. Outputs are available at the standard frequencies and may be used for calibrating receivers and wavemeters.

Marconi's Wireless Telegraph Company, Ltd.

Exhibits by Marconi's Wireless Telegraph Company, Ltd., Chelmsford, Essex are seen at the exhibition for the first time and are selected from products of the

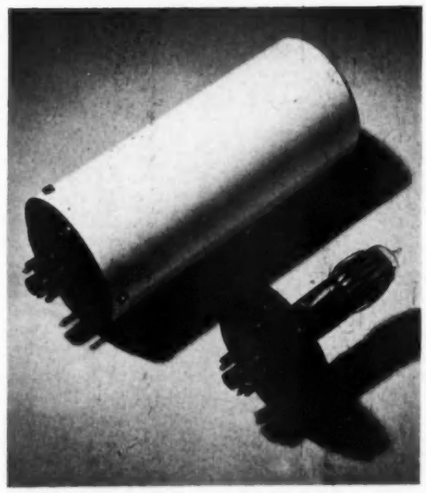


Fig. 2—Crystal oven and element. Applied heat control depends on increase in volume of naphthalene in changing from solid to liquid—Marconi's W.T. Company

recently-formed Special Components Group. We illustrate in Fig. 2 the F3006 crystal oven which makes use of the property whereby a given substance (in this case naphthalene) changes from the solid state to the liquid at a temperature which is constant for that substance. The principle of operation depends on the fact that while the melting point of the naphthalene is always a constant, the volume of the substance increases in the transition from solid to liquid. This increase is used to control the applied heat, so that in practice the temperature is maintained at the melting point and therefore stable. In other words, unlike the conventional thermostat, the change-of-state method of control exhibits a negligible cyclic temperature variation above and below the required operating temperature as the cyclic variation occurs in the proportion of solid to liquid. The operating temperature of the F3006 oven is 79·5 deg. Cent., and the time taken to come within 0·2 deg. Cent. of this is thirty-five minutes. The switching cycle at 20 deg. Cent. is twenty seconds on, eighty seconds off. Heater power supply is 24V–30V, 50 c/s, with a peak consumption of 30W. An octal base fitting is used. It is stated that a change in temperature outside the oven of 25 deg. Cent. would produce a change of only 0·1 deg. Cent. inside it.

Ferrite devices exhibited include a four-port ferrite circulator, a device which enables microwave energy to be combined and separated without mutual interaction. Energy entering port No. 1 will emerge at port No. 2 with very little attentuation ; energy entering port No. 4 will emerge at port No. 1 and similarly ports 2 and 3, and 3 and 4, are related. Microwave energy entering port No. 1 at three frequencies can be separated into its three frequency components if suitable bandpass filters are fitted to ports 2, 3, and 4. The energy which is prevented from leaving any port by the filter characteristics passes to the next port in sequence until accepted by the appropriate filter. Frequency coverage is 3·8 to 4·2 Gc/s. The circulator is designed for use with No. 11 waveguide.

Microcell, Ltd.

Instruments shown by the Electronics Division of Microcell, Ltd., Blackwater, near Camberley, Surrey, include the type 441 dielectric test set for measurements showing the behaviour of ceramics, plastics and allied materials when submitted to the influence of microwave frequencies and high temperatures. The set is available for use between the frequency range 8800 Mc/s to 9750 Mc/s and enables rapid measurements to be made of dielectric constants up to 10 and loss tangents from 0·008 upwards in the temperature range 20 deg. Cent to 400 deg. Cent., a built-in oven being provided for the latter purpose. Results can be read off at two spot frequencies by means of curves which are supplied with the instrument. The division is also showing the Type 400 " Transistorscope " (Fig. 3), a fully portable instrument that can be operated continuously for eight hours from its own battery pack if mains are not available. This is composed of high-capacity silver-zinc cells, and a charging circuit is incorporated. The Y amplifier has a bandwidth of d.c.—10 Mc/s, and to use this to the full, the timebase has a range of ten microseconds to three seconds, and in addition an " expand " facility is provided. The timebase is designed for triggered or synchronised operation.

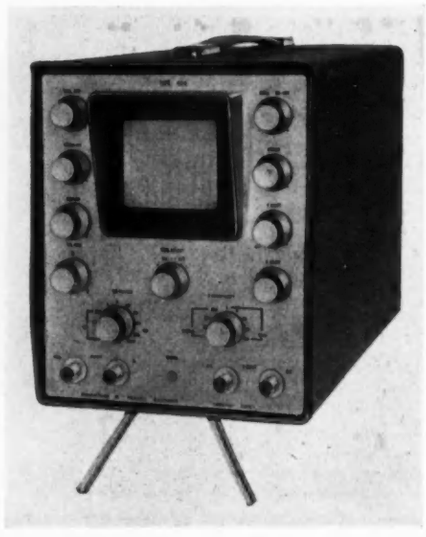


Fig. 3—Transistorised oscilloscope with built-in battery and charging unit—Microcell

Joseph Lucas (Electrical), Ltd.

We illustrate in Fig. 4 a data storage unit for the Anglo-American " Scout " satellite. The unit, shown on the stand of Joseph Lucas (Electrical), Ltd., Great King Street, Birmingham, 19, has been designed and developed for the Electron Physics Department of Birmingham University by G. and E. Bradley, Ltd., and will be used by this department in experiments to measure electron density levels along the orbital path of the satellite. Information on the maximum electron density occurring in the first ten seconds of each sixty-one-second cycle is gated into the store and read out towards the end of the period either to the telemetry system for immediate transmission, or to magnetic tape for subsequent transmission to earth at a convenient time. The sequence of operation is erase, gate, read in, store and read out, this sequence being repeated every sixty-one seconds, the timing of each operation being derived from the satellite master clock. Power consumption is very small, approaching 0·6mW per store at maximum output and derived from the satellite solar power system.

Fig. 4—Data storage unit for " Scout " satellite—Lucas

The unit, constructed in standard module form, contains eight identical stores. It is fully transistorised, containing 180 components, mostly silicon transistors and diodes, in a space 1¼in by 5¼in diameter, and weighs about eight ounces in unencapsulated form.

The stand also displays semiconductor devices and applications based on the products of the Lucas factory in Birmingham, of which sales and applications are undertaken by G. and E. Bradley, Ltd., Semiconductor Division, Electrical House, Neasden Lane, London, N.W.10. Demonstrations include the use of a Lucas silicon diode as a variable capacitor for tuning the r.f. stages of a radio receiver. A logarithmic potentiometer for varying the applied reverse voltage (of which the diode junction capacity is a function) gives linear relationship between change in capacity and angular rotation of the spindle. This application, in conjunction with a motorised potentiometer, forms the basis of an automatic tuning system.

(To be continued)

Technical Reports

Secondary Flow and Losses in a Compressor Cascade. By Jean F. Louis. Reports and Memoranda No. 3136. H.M. Stationery Office. Price 10s.—The shear flow on the annular walls of axial-flow turbo-machines is generally the primary cause of the difficulties encountered in the improvement of the performance and reliability of these machines. It creates a flow of lower momentum along the walls on which the pressure gradients developed in the main stream are impressed. Within a blade row, as a turning in the boundary layer equal to the turning of the free stream would not be sufficient to obtain the balance between pressure gradients and the centrifugal forces, the low-momentum fluid is turned more than the main fluid. This deviation in flow from the main stream is called the secondary flow.

The secondary flow results in the accumulation of the low-momentum flow on the suction side of the blades, and the axial symmetry is destroyed. Furthermore, in the above-mentioned accumulation area, a high loss core is often discernible. The experimental work described in this report shows that this loss core in the corner may not only be due to the secondary flow, as previously thought, but to the separation of the boundary layer in the corner formed by the junction of the wall and the blade where an important adverse gradient of pressure exists. These losses due to a stall in the corner will reduce appreciably the performance of the turbo-machines.

It is also reported that this kind of stall is associated with appreciable velocity fluctuations which could in certain cases initiate vibrations of blades such as flutter. Means of eliminating this sort of stall are discussed, and further study of the development of boundary layer in a straight corner formed by two semi-infinite planes at right angles is proposed, particularly in the case of an adverse gradient of pressure.

Physics Measurements During the Commissioning of "Pluto." U.K. Atomic Energy Authority Research Report No. A.E.R.E.-R3155. H.M. Stationery Office. Price 4s. 6d.—This report sets out the procedures used for the safe loading of fuel into the reactor " Pluto " during the first approach to criticality and in the first fully loaded core. As the procedure adopted was found to be very satisfactory it is thought that a fairly detailed record may be of some guidance in the initial loading of similar reactors elsewhere. It is pointed out that, as the core contains comparatively few fuel elements, the additional reactivity associated with the loading of each element is relatively large. Accordingly the possibility of very rapid rates of rise in reactivity calls for more-than-usual strictness in the adherence to a safety procedure. The report contains a description of the reactor and of the temporary modifications that were made to the safety circuits and instrumentation to adapt them for the abnormal conditions appertraining to start-up and commissioning.

A Measured Power Spectrum of the Vertical Component of Atmospheric Turbulence. By J. K. Zbrozek and D. M. Ridland. A.R.C. Current Paper No. 522. H.M. Stationery Office. Price 4s.—An experimental study of aircraft response to turbulent air is being made using power spectrum methods. Consideration is given here to the spectral technique as applied to measurements of atmospheric turbulence and a number of theoretical relationships are quoted. The spectrum of the gust vertical velocity component obtained from the first sample of turbulence analysed is discussed. There appears to be a significant difference at long wavelengths between the present measurements and those available from the U.S.A. If this difference is substantiated by further measurements it will have a considerable effect on gust load predictions for large aircraft. This stresses the urgent need for more experimental data on atmospheric turbulence, especially at long wavelengths.

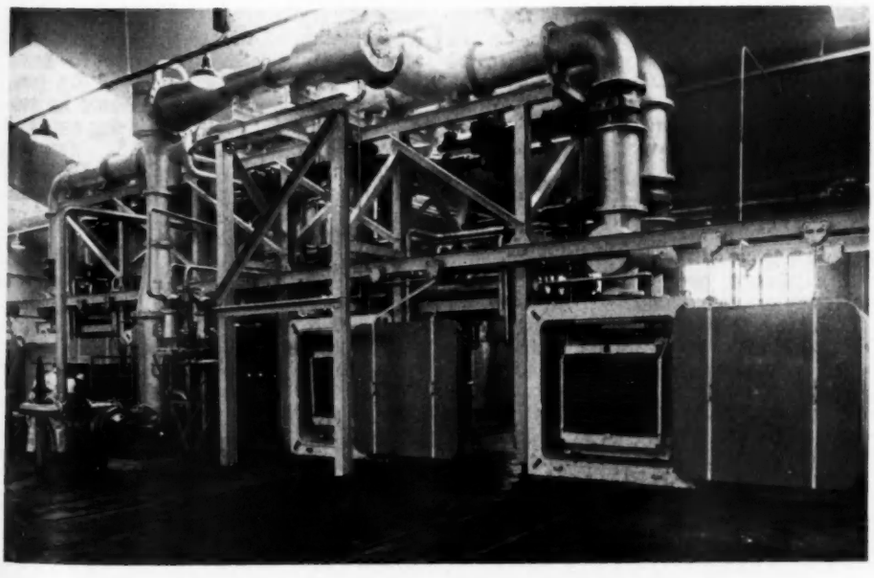
Accelerated Freeze Drying

MANY years of research by the staff of the Ministry of Agriculture, Fisheries and Food at its experimental factory at Aberdeen have resulted in the development of a new technique for dehydrating food. This new system of food preparation has been translated into engineering terms by the technical staff of Vickers-Armstrongs Ltd., so that the technique could be applied on a commercial scale. Such a plant, of which we include a general view, has been built at the South Marston Works of Vickers-Armstrongs, Ltd., for the Irish Sugar Company, Ltd., and erected at Mallow, Eire, where the company already has plant for sugar manufacture, and air drying of food, &c. This first full-scale commercial venture to produce food by the new technique has been completed recently and was inaugurated officially by Mr. Sean Lemass, the Prime Minister of Eire on Wednesday, May 24.

During drying, by hot air or by vacuum, water is drawn to the surface of the food where it evaporates and leaves a residue of salts. The loss of water and salts causes protein desaturation, plus shrinkage due to surface tension and the formation of a hard surface skin which impedes both drying and reconstitution. A more ideal method has been found to be freeze-drying since this method least affects flavour, structure, nutritive value and appearance of the food. Food prepared by this method weighs little, has a long storage life without refrigeration and can be reconstituted rapidly. However, until recently, this method owing to the high capital cost involved and the long drying period, was not economic. Now, with the development of new techniques, incorporating increased rate of transfer of heat sublimation to the food, drying times have been reduced, which makes possible the commercial application of freeze-drying. In this system water is removed in the form of vapour by sublimation from the solid phase. That is, the food is frozen and the ice converted to water vapour without passing through the liquid phase. The removal of ice by sublimation ensures that salts, &c., remain distributed in the dried food. A high rate of sublimation is achieved by processing the food in a vacuum in which the total absolute pressure is less than the vapour pressure of the ice, by supplying adequate latent heat of sublimation to the ice and by providing efficient means of removing the vapour.

The first commercially operated accelerated freeze drying plant is that which Vickers-Armstrongs (South Marston), Ltd., has built for the Irish Sugar Company, Ltd., at Mallow. The plant has been designed to process the material in the frozen state under high vacuum and associated with the application of controlled heat. As built the plant embodies a four-stage steam ejector system to maintain the vacuum while the heat is provided by hot water circulated through hollow plates. There are four drying cabinets which will be started consecutively at intervals of two hours, based on a drying time of eight hours, to give a throughput of 5 tons of "wet" food per twenty-four hours. The design of the vacuum system is based on the fact that, most foods freeze dry in the temperature range −15 to −20 deg. Cent. corresponding to an ice vapour pressure of from 1·25mm to 0·79mm Hg. so that the steam-operated air ejectors have to maintain a partial air pressure of this order. Another factor is that in batch freeze drying about 1 lb of water vapour per hour per square foot of tray area has to be extracted by the vapour removal system at a partial vapour pressure of about 0·90mm Hg. At this pressure 1 lb of vapour has a volume of 18,000 cubic feet so that a cabinet having a tray area of 36 square feet and loaded with 900 lb of food requires the system to remove approximately 100,000 cubic feet per minute.

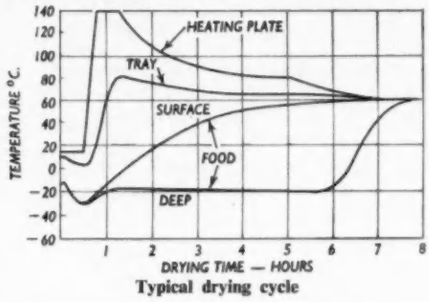
With regard to the application of heat about 1200 B.Th.U. per pound of ice sublimed is required and to achieve the highest rate of sublimation involves the application of maximum heat when the resistances to heat transfer and vapour flow are at their lowest. Direct thermal contact permits the application of maximum heat at the commencement of drying and the accelerated freeze drying technique provides a compromise between close thermal contact and the provision of adequate escape for vapour. In this system the drying cabinet consists of fifteen heating plates between which trays of frozen food, sandwiched between sheets of expanded metal mesh, are placed. The plates are connected by a link mechanism which provides for the gap between them to be adjusted so that close thermal contact is made with both upper and lower surfaces of the food. The mechanism is actuated by four hydraulic jacks which can cause a pressure of up to 8 lb per square inch to be applied to the food. Even at this pressure there remains an adequate path through the expanded metal mesh to permit the escape of vapour. Each of the plates contains two labyrinth counterflow circuits through which water, at a maximum temperature of 140 deg. Cent., is pumped at a pressure of about 280 lb per square inch, the pressure being generated in an accummulator to which nitrogen is supplied under pressure.



General view of freeze-drying food-processing plant, showing the drying cabinets with doors open

Drying Cycle

In the cycle trays loaded with food to an even thickness of ¾in are placed into a stillage which is forwarded to a J. and E. Hall air-blast freezing unit. This is fitted with a reversible axial flow fan which supplies air at a speed of 1000ft per minute, the flow being reversed every fifteen minutes. When the food is at a temperature of −20 deg. Cent. the stillage is removed from the freezer and moved to the loading position and the trays of food transferred into the spaces between the heating plates in the cabinet. The heavy sealing doors are closed and the rapid evacuation of air initiated by high capacity booster ejectors which, in three minutes, reduce the absolute pressure to 20mm Hg. Then the augmentor units are brought into operation to reduce the absolute pressure to under 1mm Hg. The pump down occupies about five minutes and by keeping this period short thawing of the frozen food is avoided. Low capacity maintaining ejectors deal with the "leakage" air load. When the total pressure in the cabinet is less than the vapour pressure of the ice in the food, sublimation begins and the food temperature is reduced to a minimum of −30 deg. Cent., as can be seen in our graph which indicates temperatures of heating plate, tray, and food temperatures at surface and at mid depth. At this point the heating plates are closed into light contact with the food and the hot water circulated to raise the plate temperature to 140 deg. Cent. within fifteen minutes. This temperature is held for thirty minutes then the circulating water is allowed to cool and the the temperature slowly falls to 60 deg. Cent. this being the maximum temperature to which food is allowed to rise the food temperature being recorded by thermocouples inserted before freezing. During drying the pressure exerted by the plates is gradually increased to a level dictated by the particular food, being dried. Drying is complete when food and plate temperatures are the same and the average drying time is eight hours. On completion of the cycle the vacuum system is shut off by motorised valves and the cabinet vacuum broken by the admission of dry nitrogen, followed by the removal of the sealing doors and the unloading of dry food to stillage. The food is packaged under conditions of low relative humidity since the moisture content of the product is about 2 per cent.



Typical drying cycle

The Mallow factory is equipped with a variety of preparation plant including a steam blancher for vegetables, built by Mather and Platt, Ltd., which inactivates enzymes and has a capacity of up to 1 ton per hour. There are also a pea washer, bean snipper, bean slicer, krant cutter and a steam peeler for root vegetables, mainly supplied by Varley Pumps and Engineering, Ltd., while outside the building a pea viner is mounted. A separate room is reserved for the preparation of meat which is stored in two cold rooms and which, after the removal of most of the fat, is cut into 2in cubes and cooked and then later minced. Steam is generated by an oil-fired "Steambloc" boiler, manufactured by Spencer-Bonecourt-Clarkson, Ltd., which is rated at 7650 lb per hour and 245 lb per square inch gauge and is supplied with water which is pumped from the river and treated in a plant supplied by the Permutit Company, Ltd.

Well equipped laboratories maintain control over the incoming raw material, material during processing and the finished product. Control is also exercised over the bacteria content and both the raw water supplies and the effluent are carefully checked, the latter in particular to avoid contamination of the river.

MAINLY METALLURGY

by T. Henry Turner, M.I.Mech.E. M.I.Loco.E. A.R.Ae.S. F.I.M.

Aluminium Sprayed Steel in Marine Conditions

By F. C. PORTER, M.A., A.I.M.*

The use of sprayed metal coatings, usually followed by a paint system, is now well established as an economic method of protecting structural steel in marine atmospheres.[1–4] *The combination of sprayed metal with paint provides the lowest yearly cost protection for most applications.*[5, 22] *Only in the last year or two has sufficient information become available to confirm the high durability of aluminium coatings in marine conditions. With zinc spray, however, useful data were available early on by comparison with the behaviour of galvanised coatings, already well established in industry. This note collates published information concerning the performances of aluminium sprayed coatings on steel, with particular reference to their corrosion resistance in marine conditions. The information, recommendations and conclusions have been accepted by the Aluminium Development Association's Research Committee and its Corrosion Sub-Committee as representing a useful appraisal of the present position.*

Introduction

ALUMINIUM coatings are now widely recognised as superior in corrosion resistance to zinc coatings of similar thickness in normal industrial, acid environments where sulphur compounds are present. Zinc is preferable in many alkaline environments. Under marine conditions aluminium coatings show technical advantages over zinc coatings in respect of improved corrosion resistance over long periods. Aluminium coatings have good compatability with organic paint systems, and economics should favour aluminium sprayed coatings.

Function of the Coating

Both aluminium and zinc coatings confer cathodic protection on the underlying steel. With zinc this mechanism of protection remains substantially constant throughout the life of the coating, which corrodes uniformly with time. Paint coatings on top of the zinc reduce the rate of corrosion, but the effect of the zinc corrosion products, more voluminous than aluminium, might be to reduce the period between repainting as compared with aluminium.

With aluminium, the coating generally becomes anodic to the steel and confers cathodic protection at the pore sites, but the insoluble aluminium corrosion products then block the pores and so reduce corrosion currents to a negligible value, thus conserving the aluminium coating.[6] The inherent corrosion resistance of the aluminium coating is enhanced by the oxide around each particle of aluminium. Hence, painting is not essential for satisfactory industrial service of sprayed aluminium coatings on steel, but painting increases the life of the coating and prevents the appearance of unsightly—but otherwise harmless—rust staining in the early days of exposure.

This slight superficial rust staining through aluminium coatings arises before penetration of the oxide skin around each aluminium particle allows full cathodic protection of the steel to take place. This staining does not however affect the protection afforded by aluminium.

With bare zinc coatings the life of the coating is directly proportional to its thickness.[7] With bare aluminium coatings, life increases more than proportionately with thickness when the coatings exceed a thin limiting value of the order of 0·002in to 0·003in.

Optimum commercial practice is to use 0·004in to 0·005in of either metal and coatings over about 0·006in are seldom applied. While painting is not essential, it increases the coating life more than a thicker layer of sprayed metal. Sprayed aluminium forms an excellent base to hold paint.

Practical Experience and Test Results

Steel vertical legs on the S.S. "President Cleveland" and "President Wilson," aluminium sprayed, impregnated and cover coated with two coats of aluminium vinyl paint were reported by Clark[8] as showing no visible deterioration of the aluminium coating after five years.

A long term test programme on sprayed aluminium and zinc coatings was started in 1954 by Clark for the Corrosion Sub-Committee of the American Welding Society.[8, 9] Exposure sites are on the East, West and Gulf coasts of the U.S.A., as well as in industrial areas where very severe corrosion conditions exist. After four years the greatest protection to steel in the following environments was given by coatings of sprayed aluminium covered with aluminium vinyl paint :

(*a*) Sea air.
(*b*) Sea-water immersion.
(*c*) Alternate sea-water immersion and exposure to air (tide level conditions).
(*d*) Industrial atmospheres contaminated with sulphur compounds.

B.I.S.R.A.[10] reports excellent behaviour of panels with 0·003in zinc or aluminium spray and painted, when exposed in tropical Nigerian atmospheres for eight years. Panels with similar thickness of aluminium spray and painted remain in excellent condition after eight years partially immersed in the polluted waters of Leith Harbour. Even sharp edges remain completely unattacked.[21]

Most other test work has, however, omitted paint finishing coats in order to obtain results in a reasonable time, although authors[11, 12] note that normal practice is to apply paint coatings over sprayed metal in a marine atmosphere.

Mansford, in discussion of Clark's paper, confirmed that sea-water immersion tests of bare sprayed coatings in Great Britain showed 0·003in to 0·004in aluminium to be better than bare zinc after four years, while Kenworthy[13] has shown that coatings 0·004in thick of both bare aluminium and bare zinc are giving good service in a marine atmosphere after ten years, although a few tiny rust spots are present on the zinc. When immersed, 0·003in zinc lasted less than four years, whereas the aluminium remains in excellent condition after nine years. Similar results are obtained under half-tide conditions. Accelerated sea-water wetting tests[14] for varying periods between nine and twenty-two months confirmed that bare zinc coatings failed extensively, while bare aluminium coatings gave good performance even though in the test of longest duration the aluminium was only 0·003in thick compared with 0·005in zinc.

Trials carried out by Hudson for the British Iron and Steel Research Association have been reported,[15] for up to twelve years in a marine environment (Calshot). At that time both aluminium and zinc (wire sprayed) remained in good condition, the coatings being 0·003in thick. No reliable data are available for powder-sprayed coatings as by error in the experimental panels supplied,the aluminium coatings contained 3 per cent copper, causing—as would be expected—relatively rapid failure.

Hoar,[7] giving results of six years tests without paint coatings, reports satisfactory results with aluminium at six sites, including two marine (Essex coast : Kure Beach), although promising results are so far obtained with aluminium-zinc alloy containing equal parts of each metal : longer term results will be of considerable interest. Harris[16] reports a preference for a composite coating (0·002in zinc followed by 0·004in aluminium) after tests for eight years on a bridge over a tidal estuary in Sydney ; zinc deteriorated by formation of white corrosion products ; aluminium was satisfactory except for traces of rust formation over part of the area, which would in service conditions be prevented by a paint coating reducing access of moisture to the basic steel. Test by Walkiden[17] however show that 99·5 per cent aluminium is preferred to aluminium alloyed with several per cent zinc, based on two years tests in salt spray.

It would appear that alloy coatings and duplex coatings may have their place in future commercial practice ; further data are needed, however, to establish their use and their limitations more closely.

An atmospheric test under the Forth Bridge by Turner[18] showed aluminium sprayed steel (without any paint finishing) to show no rust, after eleven years' exposure.

Other work[11, 12] has shown a sprayed aluminium coat 0·004in to 0·005in thick to be very effective for the protection of steel exposed to a marine environment, and even a thinner (0·003in) unpainted aluminium coating was in perfect condition after sixteen months continuous immersion in salt water.[6]

* Aluminium Development Association.

Clark[8] states that sprayed aluminium on steel gives equal, if not superior, protection against salt water corrosion to zinc spray of the same thickness.

A number of workers including Hudson have confirmed the better behaviour of aluminium than zinc sprayed coatings in normal industrial environments (for equal weight of coating, aluminium having a life four times as long as zinc).[15] Hoar[19] found slight rusting of steel in marine environments when coated with aluminium, and gave the opinion that this was due to too thin coatings particularly at sharp edges. Hudson, in referring to his own tests in marine environments says[10] (page 17) "..it now seems possible, however, that some of the aluminium coatings may have been removed prematurely after the first stage of the test..." He does not state whether this was due to edge effects or superficial rust staining. Prevention of this loss of appearance is a major reason for paint coatings on sprayed aluminium.

Tremlett and Johnson[20] have shown that steel with 0·003in aluminium coatings can be gas cut by both hand and machine methods, and welded, without removing the aluminium. No fume problems arise in welding aluminium sprayed material.

Present practice, however, is still to leave the steel bare at points where welding is necessary and spray over joints after welding.

In practice, workmen find touching up with zinc easier than with aluminium, although with the techniques now developed for preliminary grit blasting, no adhesion difficulties need arise with either metal. The relative cost of aluminium and zinc spraying depends on several factors. At present, aluminium has a basic advantage[6] as the weight of zinc is over 2·6 times that of aluminium, whereas aluminium is only 2 to 2·2 times the cost of zinc by weight.† Metal loss by weight during spraying is greater with zinc than with aluminium, but spraying rates may be slightly lower with aluminium than with zinc. For automatic spraying operation, aluminium shows a definite slight financial advantage over zinc, but for jobbing work little difference in overall cost appears to be established.

It is of interest to note one estimate that a sprayed metal coating followed by an organic coating costs only 25 to 30 per cent more than an organic coating alone[8]—which would then need to be thicker—and gives a life many times greater with low maintenance costs. Many would, however, regard this estimate of increased cost as unrealistically low. The true appraisal of the relative costs of the coatings can however only be assessed when maintenance costs are also taken into account. Stanbridge[22] in general terms, and Ballard[1] in relation to the aluminium spraying at Margam Steel Works, South Wales, clearly show the economic advantage of sprayed coating and painting as compared with painting alone.

British Standard 2569 : Part 1 ; 1955 includes both aluminium and zinc coatings for atmospheric protection.

Where protective paints are subsequently applied the specified minimum coating thickness is 0·002in with either metal. The recommendation with bare metal coatings is for 0·003in minimum zinc and 0·004in minimum aluminium. In practice, however, 0·004in to 0·005in is used, whichever metal is chosen.

In New South Wales the Department of Main Roads has specified sprayed aluminium coatings for steel bridges over tidal rivers.[16]

† March, 1961, aluminium £186, zinc £84 per ton.

Conclusions

(1) Aluminium sprayed coatings are superior to zinc sprayed coatings on steel immersed in sea-water and in half-tide conditions as well as in sulphur polluted industrial atmospheres.

(2) In marine atmospheres both aluminium and zinc give good service, but increase in required service life increasingly favours aluminium. If paint is applied, sprayed metal plus paint shows clear economic advantages in the long term as compared with paint alone.

(3) Aluminium sprayed coatings should prove cheaper as aluminium ingot is cheaper on a volume basis than zinc, while application costs are of the same order.

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The Institution of Metallurgists

THE seventeenth Ordinary Annual General Meeting of the Institution of Metallurgists was held in London on May 17, 1961, and proved to be unusually significant because after an informative discussion it approved the action of the Council in establishing a permanent Joint Consultative Committee (see THE ENGINEER, April 14, 1961, page 611).

It was only a few of the professional metallurgists in the Iron and Steel Institute (founded in 1869) and in the Institute of Metals (founded in 1908) that founded the Institution of Metallurgists in 1945. Now with its membership already over 5000 it joins the two parent bodies as their equal partner in this Joint Consultative Committee, that may lead in another decade to even more intimate amalgamation of these three bodies. Every member of the young Institution of Metallurgists will now receive the journals and other benefits of one or both of the above old-established Institutes. Some of the younger members, who have grown up in the welfare state atmosphere, regard the new compulsorily joint subscriptions as high, but the older members, who for twenty years before the formation of the new Institution had paid their own taxed money in subscriptions to the parent Institutes, regard the new rates of subscription as a very fair bargain.

The Report of Council has already appeared in print (see THE METALLURGIST, Vol. 1, No. 8, pages 260–265) and from that one learns that the registrations for the Institution Examinations numbered 1143, compared with 1096 in 1959.

The expansion in the work of the Joint Committee for National Certificates in Metallurgy has thrown an increasing financial burden on the Iron and Steel Institute, the Institution of Mining and Metallurgy, the Institute of Metals and the Institution of Metallurgists. It has therefore been arranged that the Ministry of Education, instead of the Institution of Metallurgists, shall be responsible for providing the office administration of this valuable joint committee. The status of the Institution is widely recognised ; it being represented on thirty external committees by thirty-nine representatives.

After discussion of the Council Report and the other normal business the retiring President, W. E. Bardgett, B.Sc., A.M.I.Mech.E., installed as his newly elected successor N. P. Allen, M.Met., D.Sc., F.R.S., F.I.M., who is the Superintendent of the Metallurgy Division, National Physical Laboratory, Teddington, Middlesex. In his presidential address, Dr. Allen stressed the need for up-to-date textbooks on metallurgical subjects and suggested that universities should recognise the writing of first-rate textbooks as a valuable form of research, worthy of qualifying for the doctorate degrees.

Lead

The consumption of lead has steadily increased during recent years and there have come into existence a number of organisations whose function it is to foster research and development of lead and its alloys. In April, 1961, a series of meetings were held in London to explore this field of promotional work on lead. They were attended by the heads of the lead development associations of France, Germany, Great Britain, and Italy and by a representative from the Belgian lead industry. Thus there took place an exchange of views on the main uses of lead in each of these countries.

Plans were made for a further meeting, to which representatives from other European countries would be invited. At the invitation of the Italian Institute for Lead and Zinc (Istituto Italiano del Piombo e dello Zinco) the meeting is to be held in Rome next September. It was also noted that the increasing popular concern about noise abatement has turned the eyes of lead manufacturers to the possibility of new applications for lead in sound attenuation.

Meanwhile on May 9, in London, some twenty technologists from battery and cable making companies and research organisations attended a meeting arranged by the Lead Development Association, to discuss those modifications to the mechanical properties of lead that are applicable to their industries. Dr. J. E. Hughes, Chief Metallurgist of the A.E.I. Research Laboratories, Harlow, described methods by which secondary additions can bring about changes in the characteristics of the alloys in the lead antimony system. Dr. E. J. Hooker, of Telephone Cables, Ltd., drew attention to anomalies in this system and made suggestions as to their origin.

The discussion ranged widely as N. E. Bagshaw, of Chloride Electrical Storage Company, Ltd., outlined the problems facing the battery industry, and Dr. A. J. Szper, of Varley Dry Accumulators, Ltd., spoke on the difficulties encountered by small firms when fundamental research was required. E. A. Brandes, of the Fulmer Research Institute, mentioned the difficulties of segregation in the casting of cable billets and the possibility of using nucleating agents, quoting examples from other alloy systems.

LETTERS AND LITERATURE

Letters to the Editor

WELSH HIGHLAND RAILWAY

SIR,—A group of railway enthusiasts under the leadership of Mr. R. G. Honychurch of Shrewsbury, is proposing to form a Preservation Society to restore a section of the old Welsh Highland Railway.

This line, of 1ft 11½in gauge and 23 miles in length, used to run from Portmadoc, to Dinas, near Carnarvon, in North Wales, through some of the finest scenery in that area.

All traffic ceased in June, 1937 ; the line was dismantled for scrap in 1941 and all equipment broken up or transferred to other narrow gauge railways.

It is proposed in the first instance to re-lay a 3-mile section of track. To do this, and obtain the necessary equipment, including a locomotive and one coach, will probably require at least two years' work.

Considerable support has been promised to the organisers so far, but more support still is needed, and if any of your readers are interested, and would care to write to me at the address given below, I shall be very pleased to send them further details.

G. S. CHADWICK

19, Weybridge Park,
Weybridge,
Surrey.
May 24, 1961.

MATERIALS FOR NUCLEAR ENGINEERS

SIR,—I have read with interest the review of *Materials for Nuclear Engineers* in the issue of THE ENGINEER, dated April 14. The reviewer had clearly studied the book in some detail and has provided a very fair critical review. There are, however, two very minor points on which I would like to take issue with him.

First, the absence of a comparison of the cost of enrichment of fuel with the possible design advantages is regarded as a serious error of omission. I entirely agree that such a comparison would add to the interest of the book, but the subject is a large one which could not have been taken in as an incidental, and could only have been appropriately treated in a specialist chapter. The present volume does not cover all of the ground which is of interest to the nuclear engineer, and there is the possibility of a second volume covering a number of the items mentioned by your reviewer.

Secondly, your reviewer draws the justifiable inference that data subsequent to 1959 have not been used in the book. This, in fact, is not correct. Additional material, where it was regarded as being of sufficient importance, was brought in up to and including the final proof stage which was approximately mid-1960, and in fact it is the case that the paper by Brookes, Kirby and Burke, given as reference 36 in my own chapter on magnesium, was published by the Institute of Metals in August, 1960 ; the reference "Journal of the Institute of Metals, 1959-60," Volume 88, Part 12, could understandably be mistaken for a 1959 publication.

T. J. HEAL

United Kingdom Atomic
Energy Authority,
Risley,
May 24, 1961.

MILLIONS TO BE SAVED?

SIR,—Mr. R. C. McIlleron wrote from Southern Rhodesia to plead that the railways' old-fashioned economy in applied motive power should count in their favour. Other factors do not merely "cloak" this economy I suggest : they swamp it. For a second-class fare of 2s. 5d. per passenger-mile British Railways supply a draw-bar pull of the order of 20 lb. per passenger, and lose money. B.O.A.C. dispenses thrusts of at very least 550 lb. per passenger on its "Comet" Economy services, and makes a profit, although the fare is little more than twice the rail fare. Again, as the table you published on February 24 showed, the railways of London Transport use two-and-a-half times as much fuel as the buses, per passenger-mile, calorifically. In short, one might expect the low rolling friction of railways to give them an advantage over other forms of transport, but in practice, for a variety of reasons, it does not.

From the same quarter came yet another variation of the railway propagandists' favourite equation, comparing the passenger-carrying capacity of a railway with that of a motorway. A more recent version of it, credited by *Modern Transport* to Mr. L. C. Hawkins of the London Transport Executive, stated that a single underground rail-track could do the work of sixteen lanes of motorway. Presumably this was based on an assumed rail-track capacity of 32,000 passengers per hour, for that was the figure given by London Transport to Dr. R. H. Smeed of the Road Research Laboratory for inclusion in his paper "The Traffic Problem in Towns" which he presented (not as an official R.R.L. thesis) at a meeting of the Manchester Statistical Society on February 8. The figure represented 40 trains per hour, each carrying 800 passengers, at a speed of 18 miles in the hour ; that is a phenomenon unobservable in London, but let it pass.

Each lane of a motorway has a capacity of 2000 vehicles per hour, and therefore the number of lanes required to pass 32,000 car-driving persons in one hour is sixteen ; the equation is as simple as that. But may I revise it a little to accord with the not very novel principle of comparing like with like? The trains were full ; let the cars carry four persons instead of one and the number of lanes required falls from 16 to four. Again, trains provide public transport, not private ; they should be matched against buses, not against cars. Let the vehicles be eight-seat minibuses and the number of lanes required drops to two. More realistically, let the vehicles be forty-eight-seat buses, at the reduced flow of 1000 vehicles per lane per hour, and one motorway lane is seen to be worth 1½ rail-tracks ; furthermore in buses the passengers will travel in comfort, at more than twice the rail speed.

Mr. Hawkins was quoted as saying that his equation illustrated "the immense carrying capacity of an underground or subway system, compared with road construction." As I have shown, one only has to true up his comparison in order to find that the construction of urban motorways, suitable for bus services as well as for other motor traffic, promises to result in a higher passenger-carrying capacity than the immense, theoretical capacity he has claimed for railways. Urban motorway bus services "would seem to offer advantages well worth examining closely," said Sir William Glanville nearly five years ago (*vide* my letter dated July 20, published August 12, 1960), though of course he was speaking with new motorway construction in mind, not railway conversion. Railway conversion would be the collary; for it would yield motorways, almost ready-made, precisely along the lines of maximum demand for both public and private transport, and there would perhaps be little sympathy for the out-going tenants once the falsity of their disparagement of motorways had been demonstrated.

T. I. LLOYD

Guildford,
May 26, 1961.

Book Reviews

Britain's Scientific and Technological Manpower. By GEORGE LOUIS PAYNE. Stanford University Press. Oxford University Press, Amen House, Warwick Square, London, E.C.4. Price 45s.

IN spite of its length (466 pages including appendices, bibliography and index) this is an easy book to read; but it is a difficult one to review adequately owing to the width of the ground covered and the depth of coverage. The book is—in effect—a review of the history of the development of education in this country as far as concerns the sciences and technologies. Accompanying this there are critical assessments both of the results of 100 years of neglect in these matters, and of the efforts now being made to make up for this long period of inactivity in a few years. There is also a whole chapter on research and development establishments as distinct from educational ones. The result is not reassuring but it is very realistic.

The author is an American who has had access to all sources of information on the subject, both official and unofficial. The book has been prepared for the President's Committee on Scientists and Engineers. Originally started as an annotated bibliography of official reports, it has developed

into what is probably the most complete statement ever produced on our older systems of education—technical and other—the impact on them of modern industrial and scientific needs, and of their efforts to adapt themselves to modern conditions whilst still retaining an outlook based on the past. Here also, the author is not reassuring. Whilst lip service is being paid to the need for more and better technical education, the objection of the older universities to the full development of institutes of technology on the Continental or American model—which carried the day in the arguments on these matters—is significant. It seems to show that the country is, at heart, not yet fully convinced of the necessity to earn its living in competition with Continental countries; and is not really ready to recognise the Diploma in Technology as the full equivalent in all respects of an Honours university degree. This is in spite of the fact that—here the author is quoting from *Technology*:—"The CAT scheme will have failed unless the man or woman who now teaches in a university feels it in no way a loss of status or conditions of work if he or she transfers to an advanced college." This point may be—in reality—a determining factor in our future as an independent nation. Whatever may be done in the way of tariffs, or quotas, or financial measures, the intellectual content, and the qualities, of the creative side of British industry are the things that determine our prospects of survival in the long run. This is equally true whether these resources are deployed in the economic or the military field.

The amount of tabulated statistical information is quite frightening. It is far too long to list; and it is a comfort to those who do not like statistics that the full value of the book can be savoured without them. A few samples are: the foundation dates of all the university colleges, undergraduate courses of study of state scholars, the distribution of sandwich courses, the corporate membership of the professional institutions, and the proportion of scientifically trained men in different industries. It is all of interest and convincing value. To balance this weighty mass of statistical information and well chosen extracts from all, or most of, the official reports, there are many individual views expressed. Most of these show a very penetrating insight into the weaknesses as well as the strengths of our educational systems. The spectator often sees more of the game than the players; but it is rare to find such a wide sweep combined with such deep penetration in either player or spectator.

"During Queen Victoria's reign, nine universities or university colleges were added to the two ancient universities that had sufficed England for the preceding seven hundred years. These new universities were created to satisfy a need, not to preserve a tradition. Britain's universities, Oxford and Cambridge not excepted, became, in fact, professional vocational schools. The arts education with which they primarily concerned themselves was simply the appropriate vocational training for graduates whose principal occupations would be found in the law, the church, and the administrative civil service. The transition to the sort of vocational education required by the twentieth century scientific revolution presents psychological difficulties to those who have come to regard the arts as the only proper pursuit for gentlemen and scholars, but actually does little violence to the principles on which university education has, in practice, been based."

"A share of the responsibility for the delay must also be laid at the door of some of the spokesmen for the universities, whose thinly veiled, though stoutly denied, jealousy of their university prerogatives and whose academic snobbery toward the technical colleges compounded the inevitable differences of opinion and made agreement on a course of action more difficult than it need have been."

This is a book which should be read by all concerned with education and/or professional training; and also by all who are seriously concerned in any way with our survival as an independent nation. There is nothing new in it to those who have studied these problems carefully over the last thirty years or so. To those who have not it should prove a useful eye-opener. Education in the broadest sense is indeed, in reality, by far the best investment for government finances. If really well done, all other problems can be largely relied on to solve themselves. Britain's past (and present) conviction that there is some essential significant difference between education and technical education has led her into the present economic difficulties. If these are to be surmounted, this conviction must be overcome.

Prestressed Concrete. Vol. 2. By Y. GUYON. Contractor's Record, Ltd., Lennox House, Norfolk Street, Strand, London, W.C.2. Price 95s.

THIS second volume of Monsieur Guyon's work covers the field of statically indeterminate structures or at least a great part of it and certainly that which looms large in the field of civil and structural engineering. To those who are at all familiar with the subject of prestressed concrete Monsieur Guyon needs no introduction. To others he is the doyen of designers in this material; one who is able and willing to give advice, which must be heeded, on some of the knotty problems which can arise, particularly in the field which this book covers. To appreciate the book fully one must be familiar with Volume I, since the approach to the design problems outlined in Volume II is the same as in the previous one. Thus the first chapter is chapter 19 and follows on logically from the first volume; and it is assumed that the reader is already familiar with Monsieur Guyon's method of design of statically determinate structures.

The book is divided roughly into two sections, the first dealing with the elastic analysis of statically indeterminate systems and the second with tests on such systems and the way in which ultimate load analysis may be adapted to take into account observed phenomena. In the first part the normal assumptions are made about the properties of the material since only the elastic range is considered, and, although test results sometimes indicate that modifying influences occur in certain structures, by and large this approach is perfectly adequate. In this part will be found the general theories of statically indeterminate prestressed structures such as concordant cables, transformations, lines of thrust, &c.; here, too, the design of continuous beams of various profiles and spans with various cable arrangements are considered with the aid of numerous examples. Not content with giving the theory and examples alone, Monsieur Guyon, being a severely practical man, devotes space and time to give short-cut methods in order to avoid what could otherwise become a tedious analysis of unsatisfactory designs. In the same part of the book the analysis of arches and portals is also thoroughly undertaken and a chapter is devoted to framed structures: perhaps this latter chapter will do something to allay any fears there might be about such structures—for they are extremely rare. Details of temporary joints and the relative economy (based on quantities only) of continuous and other types of construction is also examined in some detail.

The second part of the book is devoted to ultimate theory and the way in which continuous structures behave under various loads up to failure. In this section are analysed quite a number of structures and their actual behaviour is correlated with that predicted by different analytical approaches. The analyses presented, including tests on flat slabs, are quite exhaustive and it is difficult to see how any more information could be extracted from the results. As a result of this work Monsieur Guyon is able to state tentative design rules based on ultimate load calculations.

These are briefly some of the points treated in this book. We believe that anyone embarking on the design of an indeterminate structure other than of the simplest kind should study this book. It is not a book that can be read idly—there is too much meat in it and if at times it appears to be verbose this does not spring from lack of information to be imparted but rather from the thorough way Monsieur Guyon tackles any problem which confronts him. This is an essential textbook rather than one which is merely desirable.

One word must be spared for the excellent translation of Mr. Amerongen. It cannot have been an easy task but it has been done faithfully—and fluently.

Determination of the Mechanical and Technological Properties of Metals. By B. M. GLINER. (Translated from the Russian. Second edition: Translation Editor E. Bishop.) Pergamon Press, Ltd., Headington Hall, Oxford. Price 50s.

So far the Russians have received more usable technical information from our literature than we have received from theirs. The number of people in the U.K., who can read technical Russian is still very limited, and there is a shortage of adequate translations of Russian journals and books.

The 160, 5½in by 8½in, pages of this translation are illustrated by 103 line drawings that will help students. The first two-thirds of this book deal with the mechanical testing of metals on lines familiar to western thought. Ten pages are then devoted to the methods of determining the mechanical properties of weld metal and welded joints. The third section, twenty-one pages long, describes the determination of the technological properties of metals; machinability, hardenability, weldability, and miscellaneous methods such as those used for testing tubes.

When scientific and technical literature began to be freely available from the Soviet Union great difficulties were experienced by readers and translators in the matter of quantitative interpretation. There are differences in the systems of weights and measures, in the definitions of scientific terms and in the techniques used in testing, that make our reading of Russian technical books more difficult than those of France, Germany, Sweden, and Switzerland, for example, with whose methods of testing we have long been familiar.

Consequently, the advent of the first edition of this little book in 1957 was regarded as a boon to those able to read it in the original Russian. The Pergamon Press took the unusual step of commissioning a

LETTERS AND LITERATURE *(continued)*

translation, but before it could be produced the second edition of the book was issued. The original translation was therefore revised, and in order to avoid further delay of several months it has now been published in this form by non-letterpress setting and photolithography. Another unusual feature is that the Pergamon Press is voluntarily paying the Russian author the normal royalties, in the hope that their action will help to influence the Soviet Authorities eventually to pay such normal author's fees to Western authors.

The main use of this little translation will be as an authoritative source for the quantitative interpretation of the mechanical test data to be found in the Soviet literature. Because it contains definitions of the principal terms used, staff and students in technical colleges, works laboratory staff, and designers who have to study Russian methods of testing metals should find this book helpful.

Highway and Airport Engineering. By ADRIAN R. LEGAULT. Prentice-Hall International Inc., 34–36, Beech Street, London, E.C.1. Price 79s.

THIS is an ambitious book in which the author has aimed at covering in a moderately sized volume, both the theory and practice of highway and airport construction and, in addition, has devoted more than fifty pages to transportation by waterway, railway, pipe-line and conveyors. It is not surprising, therefore, that one or two subdivisions of this very wide field have been dealt with very briefly. Thus, in the short chapter on planning, the important topic of traffic surveys occupies little more than four pages, transition curves are discussed with regrettable brevity in the chapter on geometrical highway design, and the design of junctions was surely worthy of much fuller consideration than it has received.

However, there are compensations elsewhere in the book. There is, for example, frequent reference to the American Association of State Highway Officials recommendations concerning various design matters, together with the relevant numerical data; drainage problems are adequately discussed and there are excellent chapters dealing very fully with both flexible and rigid pavements, including low cost roads formed with stabilised soil. These chapters are very comprehensive and cover the materials of construction and their testing, the calculation of pavement thickness, the design of bituminous and concrete mixes, the testing of the finished products, and methods of construction.

The very informative chapter on geometrical design, adds considerably to the value of the book as a whole. A brief, but interesting, chapter deals with rubber-bitumen pavements and a further short chapter with highway and runway maintenance and snow clearance. Signs, signals and markings are discussed in some detail, both in connection with highways and airports.

The book is based, of course, on American practice, and in some respects this differs from that adopted in Great Britain. Thus the steepest cross-fall on a super elevated curve is 1 in 10 in regions where snow and ice is likely to be encountered and 1 in 8 where this risk is non-existent. In general, however, the numerical data used in speed-curvature-super elevation calculations is much the same as in Britain. It is rather surprising to note that the minimum headroom beneath overhead structures on American highways is no more than 14ft, but the practice of providing an additional climbing lane to accommodate slow vehicles on gradients is one which could be followed with much advantage on British roads.

There are discrepancies, too, in the nomenclature of bituminous materials. Thus, the American terms "asphalt" and "asphalt cement" correspond with the British term "asphaltic bitumen," and "emulsified asphalt" with "bitumen emulsion." It is noteworthy, also, that the standard American method of determining the viscosity of the more fluid bitumens and tars is by using an Engler or Saybolt-Furol viscometer; the British Road Tar Association apparatus, used in Britain and certain Continental countries, is not recognised in the U.S.A.

Part II of Professor Legault's informative book, though not strictly covered by its title, is by no means without interest. As already mentioned, this covers transport by other means than road or air and the railway section is particularly topical in view of the conditions prevailing on both sides of the Atlantic. It is stated that in 1953 the American railways incurred a deficit of 700 million dollars, but they are being reconditioned to permit of higher speeds, modernised rolling stock is being used and road-rail co-ordination is being introduced, notably by the "piggy-back" system in which semi-trailers, hauled for short distances by tractors, are loaded on to flat railway trucks for long hauls. In our own desperate efforts to cope with road congestion and railway insolvency similar co-ordination may, perhaps, offer a solution. It must be added that the illustrations in Professor Legault's book are worthy of high praise.

Foundations and Soil Properties. By ROLT HAMMOND. Macdonald and Co. (Publishers), Ltd., 16, Maddox Street, London, W.1. Price 30s.

THE subtitle of this book is "A practical guide to the methods of improving the physical properties of ground to increase its strength." It is in fact a review of current practice largely comprising descriptions of recent examples of problems in this particular branch of civil engineering. It does not present design methods nor is it a book for the soil mechanics specialist. The subjects covered are: the scope of geotechnical processes; the nature of soils; grouting; piling; freezing, heating and ground-water lowering; stabilised soil; geophysical prospecting.

Zahnräder. By DARLE W. DUDLEY and HANS WINTER. Berlin–Göttingen–Heidelberg: Springer-Verlag, Berlin-Wilmersdorf, Heidelberger Platz 3. Price DM. 61.50.

THE present book is based on *Practical Gear Design* by Darle W. Dudley (McGraw-Hill, New York, Toronto, and London, 1954), a work which on account of the wide range of expert opinion on which the author (himself a leading gear designer) was able to draw must be accounted an authoritative exposé of the present state of the art in America. In adapting the work for German readers, Dr.-Ing. Winter has rearranged it and enlarged it so as to use units, definitions, materials and standards which are current in Germany. *Zahnräder* deals with the development trends and applications in the U.S.A., and from these proceeds to the fundamentals of design, production and operation. Considering the complexities of the subject it is understandable that some aspects are only briefly sketched (e.g. hypoid gears). On the other hand, considerable space has been devoted in the final section to a discussion of practical examples, and special cases such as profile corrections, load distribution in the case of broad gears, and dynamical design.

Graphic Statics. By CYRIL S. BENSON. B. T. Batsford, Ltd., 4, Fitzhardinge Street, Portman Square, London, W.1. Price 25s.

THIS book contains the structure-diagram and the force-diagram for each of thirty-seven structures and gives in each case a figure for the load induced in each structural member by a defined system of loading. A brief preamble describes how to develop the force diagram by using Bow's notation. All the structures discussed are statically determinate and a procedure is described for copying with such configurations as may at first sight suggest statical indeterminacy.

It might have been advantageous to omit some of the examples and to use the space thus released to say something about methods of estimating the dimensions that structural members should have in order safely to withstand defined loading.

The book is excellently designed and produced.

Books of Reference

Trackwork Engineering. Edgar Allen and Co., Ltd., Imperial Steel Works, Sheffield, 9. No price quoted.—This book is intended for those responsible for the upkeep and maintenance of railway and tramway track, and has been prepared and published by a firm specialising in trackwork engineering with the aim of reflecting that firm's experience over the past sixty years, now that much railway development is in progress

A feature of the book is the inclusion of a great deal of data and tables of special interest to permanent way engineers. The subject matter reviews rail design and production, chairs and fastenings, rail joints, junctions, switches and crossings. The applications of austenitic manganese steel are discussed. There is a chapter on track laying, and information on trackwork for docks, steel works and for tramways.

The J & P Transformer Book. By S. Austen Stigant, H. Morgan Lacey and A. C. Franklin. Johnson and Phillips, Ltd., Charlton, London, S.E.17. Price 70s.—The ninth edition of this well-known book has been completely rewritten, revised and extended to keep abreast of modern practice. New chapters have been introduced on the magnetic circuit; multi-winding transformers, including tertiary windings; impulse testing of transformers; transformer oils; electromagnetic forces in transformer windings; and transformer noise. There is also a new appendix on the loading of oil-immersed transformers. The chapter on Scott connections has been enlarged to include the Le Blanc connection. In the text full account has been taken of the latest revisions of British Standards concerned with power transformers, including B.S. 171 and 148. Most of the line illustrations have been redrawn and most of the half-tone illustrations are new. As a work of reference the value of this book has been considerably enhanced.

Bi-Centenary of the Birth of John Rennie

By A. K. BRUCE, M.I.Mech.E., M.A.S.M.E.

John Rennie

IN the preface to his *Elements of the Common Law* Francis Bacon includes a passage wherein he lays down with singular felicity his conception of the obligation resting on all professional men. It is as follows :

"I hold every man a debtor to his profession ; from the which as men of course do seek to receive countenance and profit, so ought they of duty to endeavour themselves by way of amends to be a help and ornament thereunto."

Among engineers who have not failed in the endeavour referred to by Lord Bacon we surely include John Rennie, the two-hundredth anniversary of whose birth occurs on June 7. The son of a small landowner in East Lothian and destined to become one of the most distinguished engineers of his time, great interest attaches to the life history of any man who, like John Rennie, not only grew up during those years which witnessed the commencement of the industrial age in Great Britain, but was himself one of its outstanding pioneers. It is noteworthy that Rennie should have been born just six months after the blowing-in of the No. 1 blast-furnace at Carron and was not yet three years of age when the following advertisement appeared in *The Glasgow Journal* for December 1, 1763 :

"James Watt has removed his shop from the Sautmercat (Saltmarket) to Mr. Buchanan's land in the Trongate where he sells all sorts of mathematical and musical instruments, with variety of Toys and other goods."

Eight years were to separate the birth of Rennie from the date of publication of two truly epoch-making patents : Watt's patent for the steam engine with separate condenser and Arkwright's patent for the spinning frame.

However, it was not until 1776 that the installation of a Watt steam engine for operating blast-furnace blowing equipment produced really effective blast conditions for blast-furnace operation. When Rennie first opened his eyes Coulomb (born in the same year as Watt) was twenty-five years of age ; Galvani was twenty-four and Volta was sixteen. Twenty-six years were to elapse before the birth of Ohm and fifteen years before the publication, by Adam Smith, of *The Wealth of Nations*. These particulars suggest the tremendous developments in science and the industrial arts which, during Rennie's boyhood, were emerging above the horizon. At such an epoch in time the clamant need is for men endowed with qualities resembling those possessed by John Rennie. To begin with, he had from the outset a natural bent towards mechanics, this being—as was remarked by Professor Rankine—"strengthened and cultivated by his frequent visits, when a schoolboy, to the workshop of that skilful millwright Andrew Meikle." Meikle was the inventor of the thrashing-machine (patented in 1788) and of other improvements in millwork and in agricultural machinery which rendered him famous throughout Scotland ; nevertheless Rankine affirms that among Meikle's claims to distinction is "that of having been the first master of the great engineer John Rennie." While details of the education of such a man as Rennie are of particular interest, all through his life from boyhood to the end there sounds one specially resonant note : he was an incessant worker whether at school, university, or in his professional activities. To be noted as a vital part of his early industry was the use he made of vacations from school or from the university, vacations devoted to "learning the practice of mechanics from Meikle." After attending the parish school at Prestonkirk, Rennie went to the burgh school at Dunbar where he had the good fortune to study mathematics and natural philosophy under Gibson, a teacher of high quality. Rankine mentions that Rennie's success in these studies was such as to qualify him "to act as Gibson's substitute for six months, about the year 1778." His good fortune in having such a school teacher as Gibson followed him when, at the university of Edinburgh—where he spent the three years from 1780 until 1783—Rennie studied natural philosophy under John Robison and chemistry under Joseph Black, both of whom are remembered as among the friends and encouragers of James Watt.

It is to be noted that when, at the age of twenty-two, Rennie passed out of the University of Edinburgh, he had acquired an education peculiarly well calculated to equip him for the work which lay ahead. His first professional task appears to have been in connection with the design and construction of a bridge near Edinburgh. This was in 1784, a year during which Rennie came to one of the vital decisions of his life when, having been introduced by Professor Robison to James Watt—whom he then met for the first time—he was offered, and accepted, an engagement to superintend the design, manufacture and installation of the machinery at the Albion Flour Mills, London. It is to be mentioned that Rennie did not deal with the erection and starting-up of the Boulton and Watt rotative steam engines which were of the then newly introduced double-acting type equipped with the parallel motion and centrifugal governors. These engines—there were two of them—caused much dissatisfaction at the outset, some particulars of which are given in an article dealing with the Albion Flour Mills printed in THE ENGINEER for January 29, 1960, pages 189-190. All that need be emphasised here is that upon John Rennie devolved the responsibility for the design and installation of the whole of the mill machinery, a layout which was to provide, incidentally, one of the earliest examples of the employment of iron instead of timber for the shafting and frames. Rennie was also responsible for the millwright work involved by the remodelling of the drive at Whitbread's brewery, London, when during the summer of 1785 the double-acting Boulton and Watt steam engine took the place of the horse-wheel.

From the time of his arrival there towards the end of 1784 until his death thirty-seven years later John Rennie made his home in London, establishing a works of his own on the site of the Albion Mills, when they were burned down in 1791. In these works he had the assistance, as time went on, of his sons George and John, the former applying himself to the mechanical engineering side of the business, while John (afterwards Sir John) dealt with the civil engineering and consultative work. It has been said that the two sons were occupied for great parts of their professional lives "in completing the vast undertakings originated by their father." One instance is seen in the case of London Bridge, the design being due to John Rennie, though the first pile of the first cofferdam was not driven until 2½ years after his death. The bridge was opened for public traffic on August 1, 1831, after having been in course of construction—under the supervision of John Rennie the younger—for 7½ years. It may be mentioned here that the centre arch of London Bridge has a span of 152ft and rises to a height of 29ft 6in above Trinity high water mark. The total length of the bridge is 1005ft and the original width 56ft with a height above low water of 60ft. In the detailed account of London Bridge printed in his *Encyclopaedia of Civil Engineering*, Cresy—writing sometime prior to 1847—remarks that "This splendid bridge, which has not its equal in the world, reflects the highest credit on all concerned in

its erection, and, as long as it majestically spans the Thames, will be considered a masterpiece of construction." There must be many among us who mourn the disappearance of Waterloo Bridge which, designed by John Rennie and completed in 1817, was regarded by Canova as the finest bridge in Europe. No one who recalls the appearance of this beautiful structure when viewed from the embankment is ever likely to forget it. In certain other examples of his work the characteristic is not architectural beauty but sheer strength, as for instance, in the Plymouth breakwater designed and commenced by Rennie (1811) and finished under the supervision of his son John. Laid in deep water this mile-long breakwater is said to contain 3,670,444 tons of rough stone besides 22,149 cubic yards of surface masonry.

Particularly impressive about John Rennie is the importance, magnitude and diversity of the work which he accomplished in his short life of sixty years. Whether in school, in Meikle's workshop, in the University of Edinburgh or in his immense practice as a civil engineer he is surely entitled to share the tribute paid to his countryman and near contemporary the poet Thomson in that place where Dr. Johnson describes Thomson's mind as one which " at once comprehends the vast and attends to the minute." We recognise this alike in Rennie's early work on cast iron pinions ; his impact on large scale millwrighting ; his researches into the strength of materials ; the refinements proposed by him in steam dredgers and diving bells and most spectacularly in those bridges, docks, canals and breakwaters which remain as memorials to his originality and resource. In particular, they remind us of the prodigious labours which, as remarked by a biographer, caused him to take business appointments " at as early an hour as five in the morning." The intense activity which was the outstanding characteristic of John Rennie is made resonant in the exclamation of a modern poet :

> " Work !
> Thank God for the swing of it,
> For the clamouring, hammering ring of it,
> Passion of labour daily hurled
> On the mighty anvils of the world."

Active to the last, John Rennie died on October 4, 1821, at his house (now demolished) in Stamford Street, near the southern end of Blackfriars Bridge. He was buried in St. Paul's Cathedral where his grave is to be found close to the south-east corner of the crypt. Inscribed on the polished granite slab which covers the place of interment are the words :

> " The many splendid and useful works by which under his superintending genius England, Scotland and Ireland have been adorned and improved are the true monuments of his public merit."

In the grave immediately adjacent lies Rennie's second daughter, Ann Maria, who in 1828 became the wife of the distinguished architect Charles Robert Cockerell, R.A. (1788—1863), sometime surveyor to St. Paul's Cathedral. It is a touching coincidence that a yard or two away in the crypt should be buried another illustrious father and his daughter, since the grave of Sir Christopher Wren lies within a few feet of that of Jane Wren, the accomplished daughter who was long his constant companion.

(*Note :*— The pencil drawing of John Rennie made in 1803 by George Dance is reproduced by permission of the National Portrait Gallery, London. It shows Rennie at the age of forty-two years.)

Electronic Control of Machine Tools

THREE symposia at which lectures on the electronic control of machine tools were read, and demonstrations were presented, were organised by the Electronic Apparatus Division of Associated Electrical Industries, Ltd., at New Parks, Leicester, from May 16 to 19. Speakers were drawn from the division's Engineering Department. An introductory talk by Mr. M. Monks, discussed some features of machine tool design in relation to automatic control, such as the need to bear in mind that a machine controlled manually might be cutting metal for as little as 10 to 30 per cent of its working life, but one on automatic control would be cutting for perhaps 70 to 80 per cent of its working life.

A lecture on " Feed Drives and Tracer Controls " was given by Mr. R. Lawson, who outlined the principles of feedback as applied to basic Ward-Leonard schemes and those embodying electronics, with or without rotary amplifiers. By such methods finger-tip control of speed over a range of something like fifty to one was obtainable. Feedback was equally applicable to hydraulic systems, and electro-hydraulic control was useful for position as well as speed control where a high rate of response was required. Referring to steering control, Mr. Lawson remarked that this could be fitted at very small additional cost to any machine which had two feed motions under electronic control.

A lecture on " Co-ordinate Setting as an Aid to Production " was given by Mr. N. Milne, who recalled that the first installation in this country of automatic co-ordinate setting by punched cards had been made in 1955 on a Kearns horizontal boring machine, using the system developed by the British Thompson-Houston Company, Ltd. (now A.E.I.). Making some comparisons of production times with and without this facility, he mentioned the drilling under card control of 260 holes from the solid in a steel locating plate in nine hours, fifty-two minutes, plus twenty minutes setting-up time. The same component was machined on a conventional jig boring machine and the time taken was thirty-three hours.

The concluding paper was given by Mr. D. J. Meynell on " The ' Numeritrol ' System of Continuous Numerical Control of Machine Tools." In this system a planning sheet is prepared for the job, and from its information a paper tape is cut for processing in a general purpose computer. The output from the computer is a further tape on which the information is rearranged in a form more suitable for input to the " Numeritrol " director. On passing through this specialised computer, the paper tape information is converted into a recording on magnetic tape. All these tape cutting and recording processes comprise the " Numeritrol " tape service and are undertaken for the user of a " Numeritrol " equipment at a cost quoted as £7 per hour of machining time. The completed magnetic tape, together with machining instructions, are returned to the user, whose special equipment associated with the machine tool to be controlled comprises a " Numeritrol " controller through which the magnetic tape is run to operate the tool, a manual control console, and the servomechanisms and drives. The accompanying illustration shows the demonstration of " Numeritrol " control applied to a jig borer which was given during the symposium. The controller cubicle contains the tape deck ; a switch panel with ind.cator lamps showing normal operation, planned stop (i.e. a stop called for by the planning sheet) and emergency stop ; and the printed circuit boards. The adjacent console contains manual controls for the servomechanisms, providing infinitely variable milling feeds, inching, rapid traverse and similar facilities according to the requirements of particular installations.

Among the exhibits seen during the symposium were measuring bar and " Helixyn " systems for co-ordinate setting. The present " Helixyn " system, described in our June 10, 1960, issue, is applicable to a travel of roughly 5ft. An alternative, the " Racksyn," has been developed for longer travels, the fixed and moving elements being face to face so as to avoid the limitation on travel imposed by the sleeve form of the " Helixyn " moving element and the supports of the bar carrying the helix. A demonstration of " staircase " milling showed punched card control in operation. This equipment incorporates a card sequence checker attachment. Every card has a serial number punched in it, which is sensed by brushes and, if in order, allows two uniselectors to advance one step for initiating the feed of the next card. If a break in sequence is detected, the machine is stopped. In the operation demonstrated, the milling of a cam was being controlled in 0·005in steps by a sequence of 1096 cards.

A demonstration was also given of the prototype of a transistorised motor speed control system which has been developed to provide rapid response to " Numeritrol " signals. It consists basically of two transistor power packs which switch the output from a three-phase rectifier fed from the mains. The switching provides a variable-width pulse output. The pulses from the two packs are in opposition and direction is controlled by boosting one set of pulses and reducing the other.

Magnetic tape controller and manual console for magnetic tape control of jig borer

SHORTER REPORTS

D.S.I.R. Grant for Nuclear Structure Research at Oxford University

THE Department of Scientific and Industrial Research, it has just been announced, is to contribute over three quarters of a million pounds (£750,932) towards a new nuclear physics research centre at Oxford University. This is the largest single grant ever made by the Department and will provide a particle accelerator of novel design with which Professor Denys Wilkinson proposes to carry out an extended programme of long-term research on nuclear structure. In addition the National Institute for Research in Nuclear Science will carry out the design of part of the accelerator at a cost to the Institute of £200,000, which, with further aid from the University Grants Committee, brings the total government support for the project to nearly £1,000,000. This specially designed equipment will consist of an 8-10 MeV vertical Van de Graaff generator which will be coupled to a 12 MeV horizontal tandem Van de Graaff generator. With the energy that it will produce Professor Wilkinson's Group will be able to study the structure of all nuclei. It will be the first of its kind in the world. Equipment of this size and cost must be regarded as a national asset and this accelerator, while primarily provided for Professor Wilkinson's research programme, will, by agreement between D.S.I.R. and Oxford University, be available to other research workers.

The D.S.I.R. grant will cover : a 12 MeV horizontal tandem Van de Graaff electrostatic generator, to be purchased from the High Voltage Engineering Corporation of America ; a vertical 8-10 MeV Van de Graaff electrostatic generator, to be designed and built by the Electrostatic Generator Group of the National Institute for Research in Nuclear Science at the Rutherford Laboratory, at Harwell ; and the essential buildings to house the machines. This vertical machine can either be used as a high-intensity generator in its own right, or as a high energy injector in conjunction with the 12 MeV horizontal machine to give a combined energy of 20 MeV, which makes it possible to carry out experiments throughout the whole range of nuclei. It also makes possible several important types of investigation in the light elements which are denied to the lower energy.

The type of vertical generator required is not, as such, commercially available anywhere, and will be developed by the National Institute for Research in Nuclear Science. The two generators will occupy 19,000 square feet in the new Nuclear Physics Laboratory, to be built in the Keble Road Triangle, near the Clarendon Laboratory. The horizontal machine will be in the basement and the vertical in the tower. There will be an additional 6000 square feet for maintenance and experimental work and shielding for the machines.

The D.S.I.R. will also be contributing towards the running expenses. Research staff and students will eventually use the generators on a three-shift basis.

NUCLEAR STRUCTURE

According to Professor Wilkinson nuclear structure is best studied using particles accelerated by Van de Graaff generators, which give the most precise energy definition and control of any accelerating machine—considerably superior to that yielded by a cyclotron or linear accelerator for example. The steady current enables coincidence experiments to be carried out that would be impossible with the pulsed current from a cyclotron or linear accelerator. A great variety of ions can be accelerated, again in contrast with a " resonant " machine such as a cyclotron or linear accelerator. In order to study quantitatively the mechanism of a nuclear reaction, the energy of the bombarding particle must be some MeV above the repulsive electrostatic Coulomb barrier that surrounds the nucleus. The effective height of this barrier is about 17 MeV in the heavy nuclei and so the proposed energy of 20 MeV will, for the first time, open up all elements to precise study. In particular, it will be possible to interpret " stripping " patterns in the heavy elements that reveal the angular momentum with which a nucleon is inserted into a nucleus under the impact of a deuteron. This work will give information about the relationship between the shell model, in which the nucleus is pictured as a system of independently-moving individual particles, and the collective model in which the shape of the nucleus as a whole and its bulk rotation are the salient feature. Other projected studies include that of radiative capture of protons in the " giant resonance," which is well investigated by gamma-ray bombardment but whose more detailed study through the inverse process of proton bombardment is only just beginning and which is at present restricted to very few elements because of the low energy of suitable accelerators. In the light elements, the greater energy available will enable important endothermic reactions which remove a particle from the nucleus, rather than add one to it, to be studied for the first time in adequate detail to determine the distribution of " hole states." The accelerator will enable a considerable advance to be made in the study of reactions induced by heavy bombarding particles, such as ions of oxygen. These ions are very useful, in particular for " Coulomb excitation," in which the bombarding particle does not touch the target nucleus but excites it through the agency of its electric field.

THE DESIGN OF THE GENERATORS

The requirement at Oxford is for a beam of protons of energy 20,000,000 electron volts, and to provide this, the N.I.R.N.S. intends to use electrostatic generators. These machines, of which the first was built thirty years ago by Robert J. Van de Graaff, have two major virtues : precision and flexibility. The energy of the emergent particles is proportional to the voltage of the high-potential electrode, and this can be precisely controlled. Also, the charge sprayed on the moving belt can be readily varied, so that the voltage energy of the beam is flexible, and is not a fixed quantity as, for example, in many cyclotrons. However, the limitation of the generator is that voltages above 6,000,000V are not easy to achieve, and above 10,000,000V operation is very difficult. Therefore the goal of 20,000,000 electron volts is achieved in a three-stage process.

Some five years ago an old-established idea was put into practice, of two-stage acceleration by charge exchange : the accelerator was called a " tandem." It so happens that the (neutral) hydrogen atom can not only lose an electron, so becoming a proton, but can attach an electron and become a negative hydrogen ion. A tandem is an accelerator shaped like a superlative cigar, with the high potential electrode running positive at the centre. Negative hydrogen ions are injected into the machine at roughly earth potential one end, and sucked into the centre terminal at, say, 6,000,000V. Here they pass through a small quantity of material, e.g. a very thin foil ; at their high velocity, collision with the atoms of the foil causes the negative hydrogen ion to lose both its electrons, becoming a positive proton. This is then repelled back to earth, emerging with 12,000,000V energy.

The goal of 20,000,000 electron volts, however, still leaves a further 8,000,000 electron volts to be found. This will be achieved by building a second electrostatic generator, vertical this time, with a source of negative ions in its terminal. These ions are accelerated through 8,000,000V in this machine, deflected into the horizontal by a bending magnet, and injected into the horizontal tandem. In the tandem they are, as above, accelerated to 14 MeV at the centre, stripped, and then further accelerated to 20 MeV. Thus the machine as a whole has three separate stages of acceleration to reach the required 20,000,000V.

The arrangement of machines will be very flexible. Besides the compound arrangement described above, each machine will be arranged to operate separately, with its own individual target rooms. The vertical machine is considerably larger than similar machines previously built in this country : the pressure vessel will be 45ft long, 13ft in diameter, and will contain, when fully charged, 4 tons of gas.

Research Effort of D.S.I.R.

BALANCING D.S.I.R.'s research effort to meet the rapidly increasing technological demands of the present-day—and of the future—has been the main task of the Council for Scientific and Industrial Research recently. In its Report for 1960, published last week*, the Research Council emphasises that the steady expansion over the last two years—D.S.I.R. expenditure has increased from £8,900,000 in 1958-59 to £12, 200,000 in 1960-61—raises not only difficulties in the broad direction of scientific policy but also considerable administrative problems. The particular importance of ensuring that progress is balanced in relation to national needs—both industrial and academic—is emphasised and the view is expressed that strong and effective research departments must be supported in the universities " to attract good staff and students and to supply the nation with well-trained research workers." An important change in administration to give greater flexibility in long-term planning is announced. The Five Year Plan is replaced by a new method of financial forecasting, under which the Council will agree each year with the Treasury, subject to approval by Parliament, (*a*) the expenditure for the following year, (*b*) reasonably firm estimates for the next two years and (*c*) less definite forecasts for the fourth and fifth years. In this way, estimates can be revised annually.

There has been an increasing response from British universities and colleges of technology to the D.S.I.R.'s offer to provide grants for special researches. In the academic year 1959-60, the Department received over 450 applications, with a total value of £5,777,000 (compared with 300 applications amounting to £3,200,000 in the previous year). Of these, 321 grants, valued at £2,600,000 were made (281 grants totalling £2,095,000 in 1958-59). In addition, grants valued at £40,000 were awarded in the Human Sciences field of research and £298,000 on space research.

Postgraduate training awards have also increased, rising from a total of 2144 studentships in 1958-59 to 2422 in 1959-60. This figure represents about 45 per cent of all British research students in science and technology at U.K. universities and colleges. New Advanced Course Studentships are up, too—from 251 to 306. These include 77 awards of an experimental kind —" one year studentships " for specially selected students, including " lower second-class " graduates who show research promise.

Links are being strengthened between the universities and colleges on one hand and D.S.I.R. laboratories and industrial research associations on the other. In particular, this is being achieved by an interchange of staff. In 1960 there were several important transfers between the D.S.I.R. and the universities.

More universities are carrying out major research projects on a co-operative basis including integrated programmes on cosmic rays and in nuclear physics. " Such sharing of expensive research equipment is likely to become more and more advisable because it saves both money and skilled manpower," says the Council.

The Council has accepted a recommendation made by a special committee that a co-ordinated programme of research into the fatigue of structural materials should be undertaken. Discussions on how to implement these proposals are now going on between the Department and the Institution of Civil Engineers.

* The Report of the Research Council of the Department of Scientific and Industrial Research. H.M. Stationery Office, Price 4s.

SHORTER REPORTS *(continued)*

Interruption of Electrical Supplies May 15

INVESTIGATIONS by the Central Electricity Generating Board into the failure of electricity supplies on the night of May 15 over southern and south-eastern England have shown that the trouble was initiated by a switch at Wimbledon substation in South London which was automatically opened by a protective device to prevent damage to a reactor from overloading. A statement issued by the C.E.G.B. goes on to point out that, because of the lack of 275kV Supergrid connections to this area, most parts of the grid system in south and south-east England have at times to be operated at loads above those which would normally be considered prudent. On May 15 lines connecting Wimbledon and Battersea were out of service. Just before the incident the load in the area increased at an unexpected rate and was probably responsible for tipping the balance to operate the protective device on the reactor.

The power previously passing through this reactor into the south eastern area was thereupon immediately thrown on to four other circuits, on which, again due to overload, switches were automatically opened at Chichester substation and at Deptford West power station. This had the effect of isolating a section of the 132kV grid system, which ties together the power stations and bulk supply points in south east England, from the national grid and supergrid systems. On the isolated section the total demand (2726MW) was more than could be supplied from the plant immediately available (2004MW) in the power stations operating within the area. This situation in turn, brought into operation both automatic and manual controls in the power stations to shut down the generators and thus prevent permanent damage to the plant. Operating engineers throughout the area disconnected certain loads to try and prevent interruption to essential supplies. Unfortunately, the fall in speed of the generators was initially too great to allow subsequent recovery, and the blackout resulted. First supplies to consumers were restored within thirty-two minutes of failure, and complete restoration of bulk supply took place in two hours fifty-five minutes.

The C.E.G.B. statement explains that normally the operation of protective equipment on the grid system has little, if any, effect on power supply. Such automatic switching takes place frequently. The situation in the Kent and south eastern areas has arisen because of the delays in the commissioning of major 275kV Supergrid reinforcements to the 132kV system, specifically the connection across the Thames from West Thurrock to Northfleet and Canterbury and from West Weybridge to Chessington. A warning to this effect was given by Sir Christopher Hinton at the Press Conference on the Board's Annual Report, September 29, 1959, when he said:

"There is, of course, a lot of careful consideration of every transmission line that goes in. There is also a lot of opposition to many of the transmission lines. I would not like you to think that we do not welcome reasonable opposition, because, only by argument of specific cases does one get a correct evaluation of a problem of this sort. But I do think that in all of this sort of opposition one should not fail to count the cost. It is always dangerous to give specific cases of these problems, but I will run the risk of quoting the difficulty that we are in over certain transmission lines in Kent at the moment. Kent is an extremely beautiful county. It is quite natural we should meet opposition there. But lines which have been in negotiation for between two and three years there are still not approved. One result of this is that commissioning of the cross-channel cable has been put back by a year. This is a serious matter for us. I think it is even more serious from the point of view of international relations with the French Electricity Authority. I think it is serious, too, from the point of the manufacturers who have got potential export markets for d.c. transmission equipment, and who are most anxious to get our experience, and manufacturers would be the first to admit that in all technical fields to-day they do largely rely on our experience. They are anxious to get experience of that d.c. cross-channel transmission cable at the earliest possible date. Bringing it rather nearer home, let me say that unless we get clearance for those lines reasonably quickly the electricity supply to East Kent during the winter after next is going to be most gravely imperilled. This is a price paid for the argument over transmission lines which I think is sometimes insufficiently realised."

The problem has thus been to keep the risk of failure in this area to a minimum, both over winter peak periods and during the summer when it is necessary to carry out a complete overhaul of existing transmission equipment and generating plant to deal with the following winter load. Day to day operation of the system has called for a fine balance in judgment between present and future risks. In such circumstances the smallest error of judgment can trigger off a widespread failure. Under the stress of the emergency conditions of May 15, it is clear that some errors of judgment occurred. It is equally clear, from the evidence so far available, that there was no negligence on the part of the Board's staff.

The Committee of Inquiry has made the following recommendations :

1. In view of the conditions which exist in the South Eastern area and which will persist until the 275kV system is available, careful studies should be made to assist the Thames South Control staff to operate at a higher level of security. It is recognised that this will involve an additional economic penalty.

2. A study group be set up to examine the present and immediate future C.E.G.B. network and to locate points where conditions similar to those in the Thames South Area might arise.

3. A study group be set up to investigate better methods of indicating to Grid Control Engineers when potentially dangerous conditions exist on the system.

4. Further consideration should be given to the automatic disconnection of load in the event of a serious drop in system frequency.

5. The liaison between technical and operational staff should be reviewed to ensure that equipment can be used to its maximum rating without risk of premature operation of protective gear or damage to plant or equipment.

6. Methods of accelerating maintenance on transmission equipment should be examined.

PVC Pipe Systems for Building Construction

THREE systems of piping for use in building construction, which are all known by the trade name "Terrain," and which use unplasticised, unmodified PVC, have been introduced. These systems cover respectively soil and waste drainage, roof drainage, and warm air heating and ventilation. They have been put on the market as a result of co-operation between the suppliers of the raw material, I.C.I., Ltd., the designers and manufacturers of the pipe systems, A. B. Plastics, Ltd., and the distributors, Burn Brothers (London), Ltd.

PVC is considered almost an ideal material for this class of applications, due to its inertness, strength/weight ratio, &c. Two properties must be specially considered, however, namely its high coefficient of expansion, and the fact that it softens at high temperature. In practice an upper limit of temperature of about 140 deg. to 150 deg. Fah. is stipulated for the warm air heating system.

Jointing methods for the three systems depend on the use of solvents giving a "cold weld" which can be easily done. All the ancillary pieces—brackets, collars, &c.—of the systems are of PVC. In the drainage system, the fittings are of the "all socket" type, so that plain ended pipes may be cut and used in any length without waste. To facilitate jointing by solvent welding, the pipes and fittings are made to very close tolerances (±0·005in). The sockets of the fittings are tapered and the pipe is made slightly over-size so that an interference fit is obtained. Solvent cement is applied to the pipe where it also acts as a lubricant when pushing the pipe home. An expansion coupling should be used between fixed points. An access door can be fitted to the pipe or the straight portion of a branch.

[Reply Card No. 1012]

Main-Line Electrification in Kent

FROM the introduction of the summer timetable on June 12, main-line services of the Southern Region, British Railways, from London to Folkestone (including the harbour branch), Dover and beyond, *via* Tonbridge and Ashford, will be worked by electric traction. This is a further instalment in the second phase of the Kent Coast 750V d.c. electrification scheme. Since considerable engineering works and resignalling remain to be done, the electric services this year will be similar to those of the steam timetable, and revision of timings and frequencies such as those already introduced on the Kent Coast main-line *via* Chatham will await completion of the scheme in the summer of next year. For the time being, also, services from Maidstone (East) to Ashford, and from Ashford to Canterbury (West) and Ramsgate, will be worked with steam or diesel power.

On the routes now electrified, passenger services, including most boat trains, will be operated with multiple-unit stock, but the "Golden Arrow" will be formed of the existing Pullman cars hauled by a 2500 h.p. electric locomotive of the "E5000" class. Multiple-unit boat train formations will include motor luggage vans with provision for battery operation on quayside lines without a live rail.

British Railways Western Region and Commonwealth Technical Training Week

As part of its effort to assist in the success of the Commonwealth Technical Training Week, British Railways Western Region arranged a special exhibition at Paddington Station from Monday, May 29 to Friday, June 2, inclusive. Staged in a rail coach specially adapted for the occasion, the exhibition shows students and apprentices from the Mechanical and Electrical, Civil Engineering and Signal and Telecommunications Departments at work on their day-to-day tasks. Functions of other branches of railway activities are illustrated by photographs in the coach and a pictorial display is mounted on "The Lawn." The exhibition is at platform 4 and was open to the public from 10.0 a.m. to 7.30 p.m. on Monday to Thursday and remains open to 2.30 p.m. to-day. In addition to this display at Paddington, the Western Region is taking part in more than fifty other exhibitions, arranged by local authorities throughout England and Wales.

At Bingley Hall, Birmingham, the railway contribution occupies an area of 400 square feet, and includes a modern ticket printing machine, block signalling instruments with a two-aspect signal and a photographic display.

Activities at Cardiff are centred in Cathays Park, where the British Railways' stand occupies 360 square feet. Here students and apprentices are to be seen at work, with working models and photographs on view. Sixteen railway apprentices will take part in a march-past which has been arranged for the visit of H.R.H. The Prince Philip, Duke of Edinburgh, to-day.

At Swindon, in addition to participating in an exhibition at the Technical College, British Railways has opened its Locomotive Works, on May 29, 30, June 1 and to-day, for conducted tours by organised parties of school-leavers; and it will be open to the public tomorrow.

Fork Lift Attachment for Power Shovel

A VERY useful attachment for a "Dinkum" excavator has been developed by Whitlock Brothers, Ltd., Great Yeldham, Essex, to speed and ease the handling of materials on a building site. This fork lift attachment, to be seen in use in our illustration, not only facilitates the unloading of materials from lorries and stacking them on site but also their delivery to elevated working points on scaffolding. The attachment

Delivering slates to roof level with attachment on power shovel

replaces the shovel of the excavator and is quickly coupled up to the hydraulic system. Loads weighing up to 1 ton can be distributed by the machine and raised to a height of 17ft above ground level when delivering to a scaffold structure or stacking.

The normal hydraulic controls for the shovel are used and the controls are operated to maintain the angle of fork tilt as the arms raise the attachment with its load. The forks are raised and lowered in their frame, by a hydraulic cylinder through roller chains, over a distance of 5ft 10in. We are informed by the maker that the attachment can be fitted with minor modifications to all of his standard shovels.

[Reply Card No. 1007]

Tie Rods for Formwork

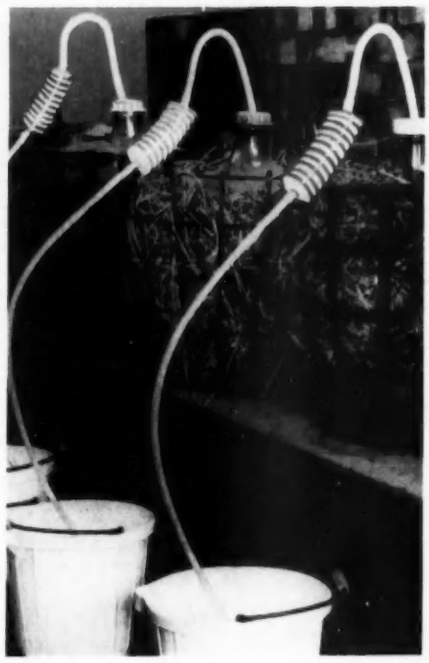
A NEW system of tie rods for use with either steel or timber formwork for reinforced concrete construction has been introduced by Kwikform, Ltd. The tie rods—known as "Kwikties"—are in two standard diameters, either $\frac{1}{2}$in or $\frac{5}{8}$in, and are supplied in the lengths required for the particular job. They are straight mild steel rods, threaded at each end with B.S.F. thread. When erecting the formwork for, say, a wall, a "connector" is screwed on to each end of the tie. The connector is a length of hexagonal bar, tapped for B.S.F. thread, with a washer at one end which is free to revolve, and a split-rivet stop driven through its centre to divide the tapped hole into two. The connector is screwed on to the tie with its washer on the inner side until it is tight against the stop. A hardwood shield—shaped as a hollow frustum of a cone and of the same length as the connector—is then fitted over the connector, which it thus encases, abutting against the washer on the inner side and the face of the shuttering on the outer side when the latter is erected. Assembly with the timber soldiers or steel formwork is then completed by screwing a bolt into the outer end of the connector. When the shutters are struck, a box spanner is inserted in the cone to grip the connector, which is then recovered, together with the cone, simply by unscrewing. Thus the tie rods themselves are the only components cast into the concrete, and many uses of the cones and connectors are achieved.

Safe working loads of 2·25 and 4·00 tons for the $\frac{1}{2}$in and $\frac{5}{8}$in ties respectively have been established from tests, the corresponding breaking loads being 4·68 and 8·75 tons. The tie lengths are $2\frac{1}{4}$in less than the finished wall thickness, the size of the connectors being 2in long, by $1\frac{1}{4}$in or $1\frac{1}{2}$in outside (washer) diameter for the $\frac{1}{2}$in and $\frac{5}{8}$in diameter sizes respectively. Single-face "ties" are available with, on the inner end, a $4\frac{3}{4}$in "tail" bent down at right angles to the rod for the $\frac{1}{2}$in tie, and a hook about $7\frac{1}{2}$in long on the $\frac{5}{8}$in tie. Water bars can be welded on the ties.

[Reply Card No. 1003]

Siphon for Dangerous Liquids

AN elementary but effective siphon has been introduced by Dohm, Ltd., 167, Victoria Street, London, S.W.1, for the safe and economical



Liquid siphon in use transferring acid from carboys to buckets

transfer of liquids from one vessel to another in industries using dangerous liquids. As shown in the illustration this syphon, manufactured from corrosion resistant polyethylene, consists simply of a tube, with a tap at one end and a concertina-like bellows pump towards the other end.

For use, the tap is turned to the closed position, the bellows are compressed and the open end of the tube is inserted in the vessel from which the liquid is to be taken. On the bellows pump being released liquid is drawn into the tube. When the tap is then closed the liquid flows freely by siphon action and the flow is under constant control at the tap.

Two models of the siphon are available, one with a bellows capacity of $\frac{3}{4}$ pint, and the other with a bellows capacity of 3 pints.

[Reply Card No. 1005]

Mining Machine Factory

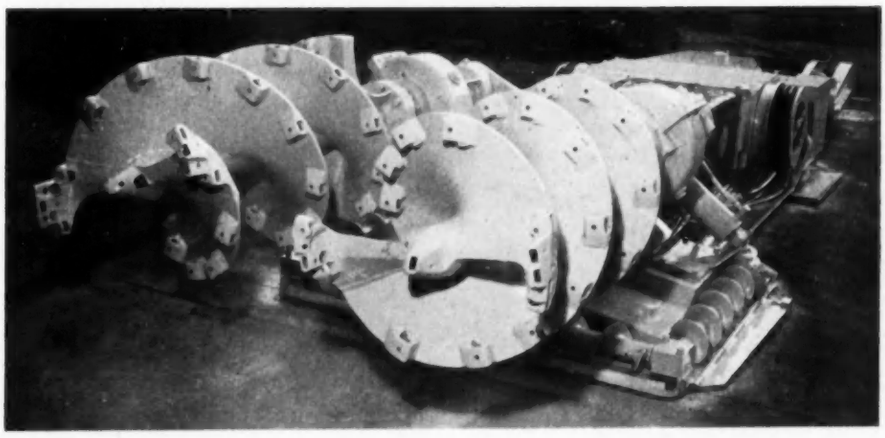
A NEW factory recently opened at Llanelly by Crawley Industrial Products, Ltd., has considerably increased the firm's capacity for the manufacture of coal mining equipment, which includes conveyors, power loading and coal cutting machines. This firm's original works at Croydon were of restricted capacity and to a large extent made it dependent upon outside suppliers for many manufactured parts. With the capacity of the new factory all production, assembly and testing can be carried out within the one establishment.

The new Llanelly works has a clear production area of nearly 100,000 square feet and is fronted by a two-storey block containing the administrative, commercial and design offices. It has two 50ft wide bays equipped for heavy and light machining, one 75ft wide bay for assembly and machine erection and a 60ft wide bay for welding and fabrication work. Each bay is served over its 302ft length by overhead travelling cranes with a 17ft 6in headroom and fork lift trucks are used extensively.

When the works were officially opened there were exhibited in the assembly bay examples of the maker's armoured conveyors and stage loaders as well as the recently developed Mark V "Midget" miner with a Mark IV machine which had just been reconditioned. The new Mark V machine, is driven by two 60 h.p. water cooled motors—compared with the single 75 h.p. motor of the earlier design. The machine has a 20in jib, and with the overall height of 12in of its power unit, it can work in a minimum height of 18in.

Another machine to be seen was the "Crawley-Wilcox" continuous auger design miner, illustrated on this page, which is intended for working in thin seams. It is assembled on the chassis of a shortwall coal cutting machine and two 41in long augers on the front can be of 21in diameter upwards depending upon seam thickness. These augers, fitted with carbide tipped bits on the front and edges, are mounted on swing casings and rotate in opposite directions. Hydraulic jacks raise and lower the augers to give the machine a working range in seams from 22in to 46in thick.

Coal cut by the augers is transferred rearwards by a boom conveyor which passes beneath the power unit of the machine. This boom conveyor is driven by a hydraulic motor and it passes coal to an independently driven bridge conveyor which is pivotally connected to its tail end.



Crawley-Wilcox continuous mining machine for use in coal seams from 22in to 46in thick

SHORTER REPORTS *(continued)*

Printed Circuit and Nameplate Production

AUTOMATIC plant for etching, and for anodising and dyeing, has been added to the facilities of Millett, Levens (Engravers), Ltd., Boreham Wood, Herts, for the production of printed circuits and other products using similar techniques of chemical engraving and anodising. The printed circuit work is in association with Printed Circuits, Ltd., an A.E.I. company, this activity dating from 1953, when preliminary study and research was carried out in conjunction with the Ministry of Supply and the Communications Research Establishment, Malvern.

The new etching and anodising installations complete a phase of reorganisation in the factory which has brought a variety of new equipment into use. During an inspection of the works on May 16 the method used for multiple reproduction of the original circuit or other design was shown in operation. The equipment comprises an exposure head which moves automatically along and across the area of the multiple master negative, in steps which are preset according to the size of the design and the number of exposures which can be accommodated in the master negative area of 25 square feet.

For photo-litho reproduction, the master is printed photographically on to a zinc plate which has been coated with light-sensitive emulsion. After development, etching and fusing, the plate is placed in an offset press (Fig. 1) and the image is transferred to the copper laminate of the printed circuit board by the normal offset process, but using a special ink resist. Two runs through the press are made where the design is such that large areas of copper have to be treated. The plate is then fused to make the printed portion fully acid resistant. Bitumen powder is spread on the board and baked in by infra-red heating. These preparations safeguard fine lines in the diagram.

Boards are then attached to carriers and suspended from the radial arms of the etching machine (Fig. 2). They are agitated gently in the acid baths disposed around the machine, and at intervals are lifted out while the whole assembly moves round one step. The rate of progression is such that four sheets come off every minute and a half. Normally the operating sequence is fully automatic under the control of process timers and electronic timing circuits in the control and instrument cubicle seen in the illustration, but provision is made for manual control if necessary. The mechanism is oil-hydraulic.

Five cleaning operations occur between etching and blanking of the boards. Etching before blanking ensures that the edges of the finished boards have at no time been in contact with acid, and is a safeguard against subsequent deterioration from this cause.

Recent developments by Printed Circuits, Ltd., outside the range of conventional electronic circuitry, have included the production by the techniques described of S-band waveguides, a printed circuit with copper conductors on "Perspex," and control system wiring for a boiler oil-firing unit. The company has also produced as a prototype a d.c. motor armature in the form of a printed circuit on a disc of glass fibre material 0·03in thick. The circuit is printed on both sides of the disc, connections between the sides being made by plating through holes. There are ninety-seven conductors, 0·004in thick, on each side, making an eight-pole, ninety-seven-turn wave winding. The conductors can be loaded up to 40A per square millimetre. This experimental armature would be suitable for a servo motor of approximately 0·2 h.p., but it is expected that similar construction could be used for powers up to some 2 h.p. at 3000 r.p.m.

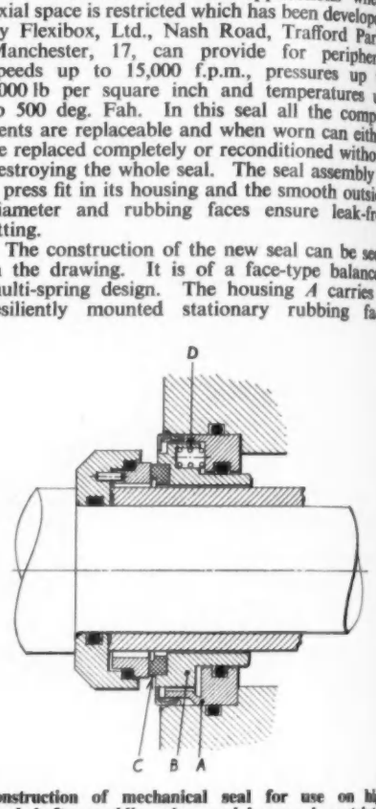
In connection with the use of printed circuits in small power applications, it is pointed out that the oil-firing controller mentioned above carries currents up to 3A on foil only 0·0015in thick, while copper foil is readily available up to 0·0045in thick, which could, in most cases, carry currents of 10A or more. At the other extreme, Printed Circuits, Ltd., is now producing microminiature circuits, strain gauges and other components, requiring extremely thin foils.

The automatic anodising and dyeing plant now operating at this works is used in the production of the chemically-engraved and anodised industrial nameplates, instrument panels escutcheons and so on in which Millett, Levens (Engravers), Ltd., has specialised since the company was formed shortly after the war. "Nameplates" in this connection is a flexible term, and among the products displayed we noted lubrication instructions and diagram for a railway point machine, and a portion of a railway signalling control panel with the track diagram and other symbols on a green background. A new product in the nameplate field shown during the visit to the works was "Magnoplate," consisting of nameplates on a PVC base with a ferric powder backing, for temporary attachment to ferrous surfaces.

Mechanical Seal for High-Speed Shafts

A MECHANICAL seal for applications where axial space is restricted which has been developed by Flexibox, Ltd., Nash Road, Trafford Park, Manchester, 17, can provide for peripheral speeds up to 15,000 f.p.m., pressures up to 1000 lb per square inch and temperatures up to 500 deg. Fah. In this seal all the components are replaceable and when worn can either be replaced completely or reconditioned without destroying the whole seal. The seal assembly is a press fit in its housing and the smooth outside diameter and rubbing faces ensure leak-free fitting.

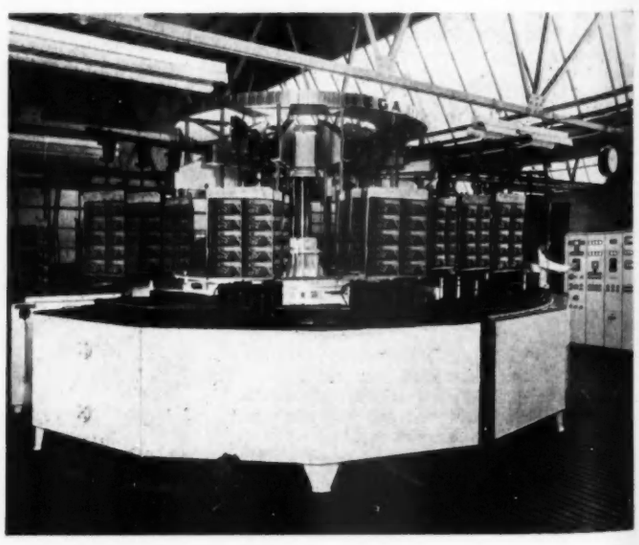
The construction of the new seal can be seen in the drawing. It is of a face-type balanced multi-spring design. The housing *A* carries a resiliently mounted stationary rubbing face



Construction of mechanical seal for use on high speed shaft assemblies where axial space is restricted

assembly consisting of a body *B* insert *C* and resilient packing *B*. Face loading is provided by a number of small springs *D* arranged around the flange of the stationary seal ring body. The rotary mating face should preferably be resiliently mounted. The three variants of the basic design which are available are fitted with "O"-rings, chevron packed and "reverse balanced," respectively.

[Reply Card No. 1002]



(Left) Fig. 1—Offset litho machines printing circuits on to copper-clad laminate (Right) Fig. 2—Printed circuit boards mounted for processing on the automatic etching machine

INDUSTRIAL NEWS

Engineering Production

Production in the engineering industries continued to rise in March, the Board of Trade announces. It has been provisionally estimated that the volume of production in the engineering and electrical goods industries in March was 2 per cent more than a year earlier and, in the first quarter of 1961, 3 per cent more. Allowing for the loss of production on Good Friday, which fell in March this year, the increase was about the same as in the fourth quarter of 1960.

The volume of net orders received by the industries producing engineering and electrical goods, locomotives and railway track equipment, railway carriages and wagons, heavy commercial vehicles and wheeled tractors was 17 per cent more than in March, 1960, and in the first quarter 6 per cent more than the very large volume a year earlier. Whilst export orders increased in March, the Board points out that in the quarter they were 3 per cent less than a year earlier. Apart from some large orders placed in March, for a new power station, home market demand for plant and machinery, the Board says, has grown strongly in the opening months of 1961.

Overseas Trade

The final figures published by the Board of Trade for United Kingdom trade in April show that exports were valued at £318,600,000, imports at £355,200,000, and re-exports at £12,700,000. Because of the strike of tally clerks at the London docks in September and October last year, figures for the last three months are compared with the five-months period September, 1960 to January, 1961, the total figures for which are not distorted by the short term effects of the strike.

In the last three months, the Board says, after eliminating normal seasonal variation, United Kingdom products were being exported at a rate 1½ per cent above that of the previous five months. Exports to Western Europe and to the Soviet Union and Eastern Europe increased in the last three months compared with the previous five months, but there was a fall in exports to the sterling area, particularly Australia. Exports to other areas were little changed. Exports to the United States continued to fall and were 35 per cent less than a year earlier, but exports to Canada increased, by more than can be accounted for by the delivery of the "Empress of Canada," the Board adds, and were 17 per cent more than a year earlier. Exports to member countries of the European Economic Community increased by 8 per cent compared with the previous five months, but there was a 2 per cent fall in exports to other members of the European Free Trade Association.

The increase in exports was due to a substantial increase in exports of engineering products, apart from cars, the Board states, but there were, it suggests, signs of some recovery in car exports in April. Exports of non-electric machinery were 14 per cent more than a year earlier, and of electric machinery and appliances 9 per cent more. In addition, there have been large exports of ships in the last three months, including, in April, the "Empress of Canada." Exports of chemicals were 5 per cent more than a year earlier, the Board says, but seem not to have been rising lately. Exports of commercial road vehicles in the period February to April were 27 per cent more in value than a year earlier, and this follows increases of some 20 per cent on a year earlier throughout the preceding year. Exports of cars in the last three months were 51 per cent less than a year earlier.

Compared with a year earlier, the Board says, imports of iron and steel were down by by 41 per cent and of non-ferrous base metals by 18 per cent. Imports of fuels, mainly petroleum and petroleum products, had risen sharply towards the end of 1960, but in February to April they were 1 per cent less in value than a year earlier. In the last three months imports of non-electric machinery were 30 per cent more than a year earlier, and imports of electric machinery and appliances 21 per cent more.

Unemployment

According to the provisional figures issued this week by the Ministry of Labour, the number of unemployed in Great Britain on May 15 was 299,272, of whom 282,233 were wholly unemployed and 17,039 were temporarily stopped from work. Unemployment, expressed as a proportion of the estimated number of employees, was 1·3 per cent in May, compared with 1·5 per cent in April, 1961 and in May, 1960. The number of unemployed fell by 40,789 between April 10 and May 15, 1961, the Ministry says, there being decreases of 39,630 in the number wholly unemployed and of 1159 among the temporarily stopped. Unemployment fell by 31,839 among adults and by 8950 among boys and girls.

Excluding school-leavers, the number wholly unemployed fell by 32,015 since April 10 to 280,375, the normal seasonal decrease, the Ministry points out, is about 18,000. In the two previous months the corresponding changes were a decrease of 8148 between March and April, compared with a normal seasonal decrease of about 22,000, and a decrease of 18,110 between February and March, compared with a usual seasonal decrease of 18,000.

The number registered as unemployed in Northern Ireland on May 15 was 35,536, which is 7·4 per cent of the estimated number of employees.

In the five-week period ending May 10, 1961, employment exchanges in Great Britain filled 205,691 vacancies. The number of vacancies notified to exchanges but remaining unfilled at May 10 was 353,519, which was 16,509 more than in April. The normal seasonal increase between April and May, the Ministry says, is about 3000.

Wages and Hours

Changes in rates of wages and hours of work reported to the Ministry of Labour as having come into operation in the United Kingdom during April are estimated to have resulted in about 709,000 workers receiving an aggregate increase of approximately £317,000 in their full-time weekly rates of wages, whilst about 285,000 workers had their normal weekly hours reduced by an average of two hours.

The latest statistics published by the Ministry of Labour show that adult manual and semi-skilled engineering workers employed by local authorities in England and Wales received increases ranging from 6s. 11d. to 14s. 10d. a week, according to classification. An arbitration award of a weekly increase of 11s. to adult operating staff in municipal passenger transport undertakings was accepted by the Joint Industrial Council for the industry. Workers employed in the iron, steel and non-ferrous scrap industry received increases of 2d. an hour for men with proportional amounts for other workers. Increases of varying amounts, resulting from a re-classification of occupational groups, became payable to certain male workers in petroleum distribution. Through the operation of sliding-scale arrangements, based on the official index of retail prices, increases of varying amounts also became payable to workers in a number of industries, including iron and steel manufacture.

Of the total increase of £317,000, the Ministry of Labour states, about £297,000 resulted from arrangements made by Joint Industrial Councils or other joint standing bodies established by voluntary agreement, £11,000 from Wages Regulation Orders, £5000 from direct negotiations between employers and trade unions, and the remainder from the operation of sliding scales based on the official index of retail prices.

Stoppages of Work Due to Industrial Disputes in 1960

Detailed statistics regarding stoppages of work arising from industrial disputes in the United Kingdom during 1960 have been published in the May issue of the *Ministry of Labour Gazette*. The statistics relate to stoppages due to disputes connected with terms of employment or conditions of labour, and the number of such stoppages which came to the notice of the Ministry as beginning in 1960, was 2832 compared with 2093 in the previous year. Seventeen other stoppages which began in 1959 continued into 1960, is that the total number in progress in 1960 was 2849. The corresponding figure for stoppages in progress in 1959 was 2105.

The aggregate number of workers involved in stoppages in progress in 1960 was estimated at 819,000, of whom about 701,000 were directly involved and 118,000 were indirectly involved, in 1959 the figure was 646,000, of whom about 522,000 workers were directly involved and 124,000 were indirectly involved.

As the total number of workers shown as involved in stoppages is obtained by aggregating the numbers involved in separate stoppages during a year, the Ministry points out, that some workers who were involved in more than one stoppage have therefore been counted more than once. It is estimated, the Ministry says, that the net number of individuals involved in stoppages in 1960 was 632,000, compared with 504,000 in 1959. On the basis of the estimated net numbers, this represents nearly five working days lost per worker involved in 1960 as compared with about ten and a half days in 1959.

The aggregate number of working days lost in 1960 through stoppages in progress in that year has been estimated at 3,024,000, compared with 5,270,000 in 1959.

PERSONAL AND BUSINESS

Appointments

MERRYWEATHER AND SONS, Ltd., announces that Mr. Leonard R. Parker has been appointed a director.

MR. C. R. THOMPSON has been appointed an executive director of Pye T.V.T., Ltd., Cambridge.

H. S. CATTERMOLE AND CO. (HYDRAULICS), Ltd., has appointed Mr. Norman King as chief engineer.

MR. JOHN E. ABEL, sales manager of George Richards and Co., Ltd., has been appointed a director of the company.

A. G. WILD AND CO., Ltd., has appointed Mr. R. S. Leyshon as its sales representative in the south western and south eastern division of the N.C.B.

ASSOCIATED ELECTRICAL INDUSTRIES, Ltd., has appointed Mr. R. F. Marshall as central education manager and Mr. D. Baird as central personnel manager.

MR. W. F. OAKLEY has been elected chairman of the Telecommunication Engineering and Manufacturing Association. Mr. W. G. Patterson has been elected vice-chairman.

HILGER AND WATTS, Ltd., announces that it has recently appointed two more representatives ; for Scotland, Mr. Alastair Campbell, and for the Midlands, Dr. E. R. Sayer.

BRITISH INSULATED CALLENDER'S CABLES, Ltd., has announced the appointment of Mr. A. W. Thomson, A.M.I.E.E., as technical manager of B.I.C.C.—Burndy, Ltd., Prescot, Lancs.

MR. W. R. HURLEY has been elected chairman of the Cold Asphalt Association for the year 1961–62, in succession to Mr. C. Knight. Mr. H. M. Lewis has been elected vice-chairman.

MR. M. C. LLOYD has been appointed chairman of the research committee of the British Steel Castings Research Association following the resignation from this office of Dr. E. Gregory.

MR. CYRIL SMITH, contracts manager of the resistor division of Fawcett Preston and Co., a member of the Metal Industries Group, has been appointed sales manager of the division.

MR. J. A. E. TRINDER has been appointed Group sales director of the Turriff Group of Companies. He remains also on the board of George E. Taylor and Co. (London), Ltd., a member company of the group.

CONSOLIDATED PNEUMATIC TOOL COMPANY, Ltd., has announced the following appointments to its board of directors : Mr. S. H. Ireland, assistant managing director ; Mr. L. S. Bright, financial director, and Mr. A. O. Miller, director.

MR. P. W. E. HOLLOWAY has succeeded Mr. A. J. Hill as chairman of the Federation of Civil Engineering Contractors. The new vice-chairman is Mr. G. F. Egan. Mr. W. G. Mitchell has been re-elected President of the Federation for a second year.

MR. C. E. WRANGHAM, until recently deputy chairman of Davy-Ashmore, Ltd., is to be appointed chairman of Short Brothers and Harland, Ltd. Mr. C. F. Uwins, who has held the position on a temporary basis since September, 1960, will remain a director of the company.

CAMBRIDGE INSTRUMENT COMPANY, Ltd., states that Mr. K. J. Bush, A.M.I.E.E., has been appointed assistant sales manager, mechanical thermometer division, Friern Park, North Finchley. The appointments of the following assistant resident engineers have also been announced : Mr. W. C. Orford, Nottingham ; Mr. S. V. J. Crump, Bristol, and Mr. W. A. Hall, Manchester.

LONDON TRANSPORT announces two appointments. Mr. R. Dell, M.I.E.E., M.I.Mech.E., M.I.R.S.E., has been appointed a chief officer of the London Transport Executive, with the title of chief signal engineer. He will act under the general direction of Mr. C. E. Dunton, M.I.C.E., chief civil engineer. Mr. W. H. Challis, M.I.R.S.E., has been appointed an officer of the Executive, with the title of signal engineer, and acting as deputy to the chief signal engineer.

FOLLOWING the acquisition of Standard-Triumph International by Leyland Motors, Ltd., it is announced that in order to integrate the operation of the two companies, Sir Henry Spurrier has become chairman of Standard-Triumph International, Ltd., with Mr. Alick S. Dick continuing as managing director. Mr. S. Markland, Mr. S. Baybutt and Mr. D. G. Stokes have also joined the Board. It is further announced that Mr. A. S. Dick and Mr. S. B. Dixon have been invited to join the Board of Leyland Motors, Ltd.

C. H. JOHNSON (MACHINERY), Ltd., states that Mr. R. O'Neill, joint managing director and general sales manager, has retired after forty-eight years with the company. Mr. R. A. Battine has been appointed sales director of the contractors plant division, and Mr. C. H. Neesom is sales director of the materials handling division. Mr. E. S. Pitcher is now sales manager, London and Home Counties area.

CASTROL, Ltd., announces that the particular interests of the four new assistant managing directors whose appointments take effect from January 1, 1962, have now been defined and will be as follows : Mr. J. A. V. Watson, industrial trading (United Kingdom), research, technical development, aviation, motor manufacturers' department ; Mr. L. G. Packham, Castrol trading (overseas), industrial trading (overseas), purchasing (overseas), production (overseas) ; Mr. C. E. R. Millidge, Castrol trading (United Kingdom), engineering division ; Mr. A. A. Barr, publicity, competitions, purchasing (United Kingdom), production (United Kingdom), projects and development.

THE ELECTRICAL RESEARCH ASSOCIATION announces the composition of Divisional Committee No. 2—Power Plant : Mr. E. S. Booth, chairman (Central Electricity Generating Board) ; Dr. A. T. Bowden (C. A. Parsons and Co., Ltd.) ; Mr. J. Caldwell (The English Electric Company, Ltd.) ; Mr. W. W. Campbell (Merz and McLellan) ; Dr. W. H. Darlington (Associated Electrical Industries, Ltd.) ; Mr. F. Dransfield (Central Electricity Generating Board) ; Mr. G. Gemmill (Central Electricity Generating Board) ; Mr. J. B. Jackson (Central Electricity Generating Board) ; Mr. E. Hywel Jones (South of Scotland Electricity Board) ; Mr. K. J. McKillop (Water-Tube Boilermakers' Association) ; Mr. J. Mayer (International Combustion, Ltd.) ; Mr. J. M. Mitchell (The General Electric Company, Ltd.) ; Mr. C. W. Priest (Central Electricity Generating Board) ; Mr. W. F. C. Schaap (Babcock and Wilcox, Ltd.). Dr. H. G. Taylor, director of the Electrical Research Association, is an ex officio member of the Committee, and the secretary is Mr. G. A. W. Taylor of the Electrical Research Association.

Business Announcements

FERRO CORPORATION, parent company of Ferro Enamels, Ltd., Wombourn, Wolverhampton, has acquired full ownership of its French affiliate in Paris, Procédés Ferro.

HONEYWELL CONTROLS, Ltd., has announced that its Middlesbrough branch has moved to new premises at 59/60, Albert Road (telephone, Middlesbrough 4.43.31 and 4.43.32).

COCKBURNS, Ltd., Cardonald, Glasgow, is to act as British selling agent for pressure gauges, thermometers and special control instruments manufactured by the E.N.F.M., Company of Schiedam, Holland.

ALLIED IRONFOUNDERS, Ltd., announces that owing to differences of views on policy, Mr. H. C. Wilson Bennetts has, by mutual agreement, resigned from the board of the company with effect from May 31.

CAWKELL RESEARCH AND ELECTRONICS, Ltd., Scotts Road, Southall, Middlesex, has appointed Hird-Brown, Ltd., 244, Marsland Road, Sale, Cheshire, as its official agent for the counties of Cheshire, Yorkshire, Durham, Lancashire, Westmorland, Cumberland, Northumberland and North Wales.

KEARNEY AND TRECKER—C.V.A., Ltd., Garantools House, Portland Road, Hove, states that with the exception of Cincinnati press brakes and shears, all machine tools previously sold by E. H. Jones (Machine Tools), Ltd., Hove, are now handled directly by the sales department of the parent company, Kearney and Trecker—C.V.A., Ltd.

C. H. JOHNSON (MACHINERY), Ltd., states that its Australian branch has been formed into a subsidiary company, C. H. Johnson (Machinery), Pty., Ltd., with head office and works at 593, Waterdale Road, West Heidelberg, Victoria, Australia. Mr. F. Blackshaw has been appointed a director of the company, and will be its general manager.

TELCO, Ltd., announces that its factory, warehouse and London offices will be all under one roof at Enfield from June 5. The offices and warehouse, previously at 3, Newman Street, London, W.1, and the factory, previously in Balls Pond Road, London, N.1, will be operating at Alma Road, Enfield, Middlesex, from that date. The new telephone number will be Howard 1282 (10 lines).

THE PLESSEY COMPANY, Ltd., confirms that it has acquired the Eastern Avenue, Romford, factory of Regentone Products, Ltd., for £507,000. Plessey has also entered into an agreement with Regentone whereby Regentone and R.G.D. radio and television models will be made by Plessey to Regentone specifications. These sets will continue to be marketed by Regentone. Plessey will use the Romford factory for the extension of its activities in the Ilford area, and will offer alternative employment to the bulk of the people previously employed there.

HUNSLET (HOLDINGS), Ltd., Leeds, 10, has acquired the whole of the share capital of Materials Handling Equipment (Great Britain), Ltd., of Maidenhead and London. M.H.E. manufactures "Kestrel" and "Falcon" side-operating fork lift carriers, and is also the sole concessionaire in the United Kingdom for the "Traveloader" heavy duty side-operating fork lift transporters, made by Otis Elevator Company of U.S.A., the "Lizard" electric side-operating reach trucks made by Albert Irion Nachfolger of West Germany and the "Valnet" super straddle carriers made by Valmet Oy of Finland.

Awards

DR. E. EASTWOOD, M.I.E.E., director of research at the Marconi Research and Development Laboratories at Great Baddow, has been awarded the Wakefield Gold Medal by the Royal Aeronautical Society. The award is in recognition of his contributions towards safety in the air by the development of air traffic control and navigational aids. The medal will be presented to him on the occasion of this year's Wilbur Wright Memorial Lecture on September 12.

THE INSTITUTION OF CIVIL ENGINEERS announces that Sir Owen Williams and his son, Mr. O. T. Williams, have been awarded the Telford Gold Medal for the 1959–60 session, for their joint paper "The London–Birmingham Motorway (Luton–Dunchurch : Design and Execution)." The James Watt Medal has been awarded to Mr. P. Chalmers and Mr. A. C. Layhe jointly (co-authors with Mr. Arthur Dean) for their paper "The Mechanisation of Railway Civil Engineering Maintenance Work." The George Stephenson Medal has been awarded to Mr. G. M. Binnie, Mr. J. G. Campbell, Mr. N. H. Gimson, Mr. P. F. F. Lancaster-Jones and Mr. C. A. Gilliott, joint authors of the paper "The Dokan Project : the Flood-Disposal Works and the Grouted Cut-Off Curtain." Mr. W. N. Allan and the late Mr. H. A. W. Morrice have been awarded the Coopers Hill War Memorial Prize for the paper "Planning for the Ultimate Hydraulic Development of the Nile Valley."

Contracts

TARMAC CIVIL ENGINEERING, Ltd., has been awarded a contract worth approximately £108,000 by Rotherham Borough Council for the construction of 1¼ miles of 24ft single carriageway road at Fenton Road, Rotherham.

BRAITHWAITE AND CO. (STRUCTURAL), Ltd., and ALEX. FINDLAY AND CO., Ltd., have been awarded contracts of a total value of about £1,500,000 for steelwork for the new Tinsley Park works, Sheffield, being built for the English Steel Corporation, Ltd.

THE POWER-GAS CORPORATION, Ltd., has received a contract from the Southern Gas Board for a 900,000 cubic feet capacity Wiggins dry seal gasholder for the Bognor Regis gasholder station. The new holder will replace a 500,000 cubic feet three lift spiral gasholder built in 1911. It will be 106ft in diameter by 130ft high and will be made smaller in diameter and taller than a standard 1,000,000 cubic feet Wiggins gasholder, as it has had to be specially designed to fit on the foundations of the old spiral gasholder.

A. MONK AND CO., Ltd., has received a £675,000 contract for construction of a factory extension to the Salford warehouse and offices of Colgate-Palmolive, Ltd. The contract involves site clearance, construction of a basement and five-storey factory extension to the existing building at Ordsall Lane, Salford. Other recent contracts awarded to A. Monk and Co., Ltd., also include a contract valued at £143,000 to be completed in twenty-nine weeks, for the construction of a single-storey factory for Taylor Controls, Ltd., at Stevenage, Hertfordshire.

G. AND J. WEIR, Ltd., the Glasgow engineers, is to install another "Multiflash" sea water distillation plant for the Kuwait Oil Company, Ltd., at Mina-el-Ahmadi, Persian Gulf. It will consist of a single twenty-one stage plant measuring 58ft long, 19ft 6in wide and 18ft high with an output of 600,000 imperial gallons of fresh water a day. Two similar installations were commissioned last year, one of which was the world's largest "flash" type plant, for the Government of Kuwait, producing 2,000,000 gallons daily. Erection of the new installation is to be completed in November this year, forty-three weeks from the date of order.

Inner Harbour at Port Kembla

By OUR AUSTRALIAN CORRESPONDENT

THE opening of the inner harbour at Port Kembla (N.S.W.) to the ore carriers of Australian Iron and Steel Pty., Ltd., completes a further stage (see THE ENGINEER, June 10, 1960) in the development of port facilities in the Wollongong area by the State Public Works Department.

The existing outer harbour, consisting of a Northern and an Eastern overlapping breakwater does not provide all weather anchorage. The new inner harbour, dredged and excavated from the land-locked Tom Thumb Lagoon, is entered through a 36ft deep by 400ft wide channel, and the first stage, 141 acres in area, will provide seventeen deep-water berths, while a further extension of 82 acres is planned, with an additional twenty berths as shown above and overleaf.

The Tom Thumb Lagoon drains a catchment of 25 square miles of coastal foothills, and this precluded the use of cofferdam construction without adopting a complex alternate drainage system to the north, where the city of Wollongong abuts on to the present lagoon limits. As dredging and underwater excavation would permit of the progressive use of the new facilities, model investigations of wave and surge action for several stages of the project were used to design the best entrance consistent with low wave energy transfer from the outer harbour.

Dredging to date exceeds 5,000,000 yards, and 450,000 yards of the underlying rock have been blasted and excavated. A berth adjacent to the new blast-furnace for the interstate ore carriers has been achieved, future developments will include the making of the southern shore line as a mooring for small craft, and in the western basin

The Broken Hill Proprietary Company, Ltd.'s "Iron Yampi" entering the new Inner Harbour at the official opening. Port Kembla steelworks in the background

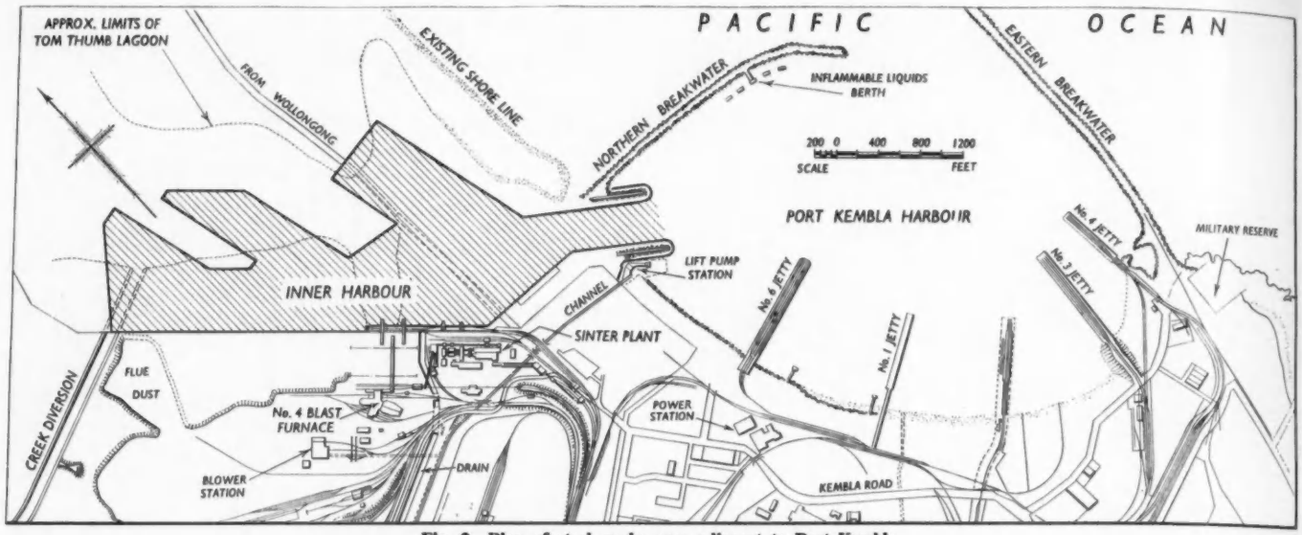


Fig. 2—Plan of steel works area adjacent to Port Kembla

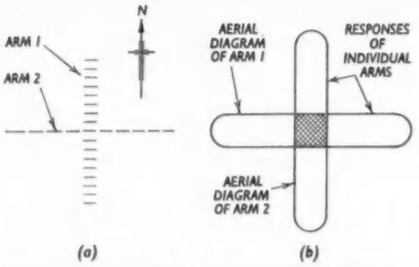
general purpose wharves and coal loading facilities. Coking coal is delivered to the steel works from five collieries working coal seams outcropping in the escarpment a few miles inland.

Radio Astronomy Centre

A RADIO ASTRONOMY CENTRE has been established in the University of Sydney. The Centre will build one of the world's largest and most powerful radio telescopes. To date, most of the Australian work in this field has been carried out by the radio astronomy group of the Radio-Physics Division of the Commonwealth Scientific and Industrial Research Organisation C.S.I.R.O.).

In the study of cosmic radio frequency radiation, it has been observed that in addition to sources of an angular size less than about ½ deg. extended sources of considerably greater size exist. For accurate analysis, pencil beam aerials of high resolving power are desirable, but are far too large to be built in a completely steerable form, as with the 210ft diameter paraboloid dish now being constructed at Parkes, New South Wales. The radio telescope needed by the Centre would require a major dimension of about 1 mile, and the most suitable for this is a cross-like structure invented by Dr. Mills. Professor Harry Messel, Head of the School of Physics, has announced the decision to build a Mills Cross radio telescope, whose two parabolic antennae would each be a mile long and 40ft wide, at an estimated cost of £A300,000.

The telescope (below) physically comprises a cruciform arrangement of two long rows of dipoles backed by parabolic reflecting screens, lying in the north-south and east-west directions respectively. The dipoles in the east-west arm are

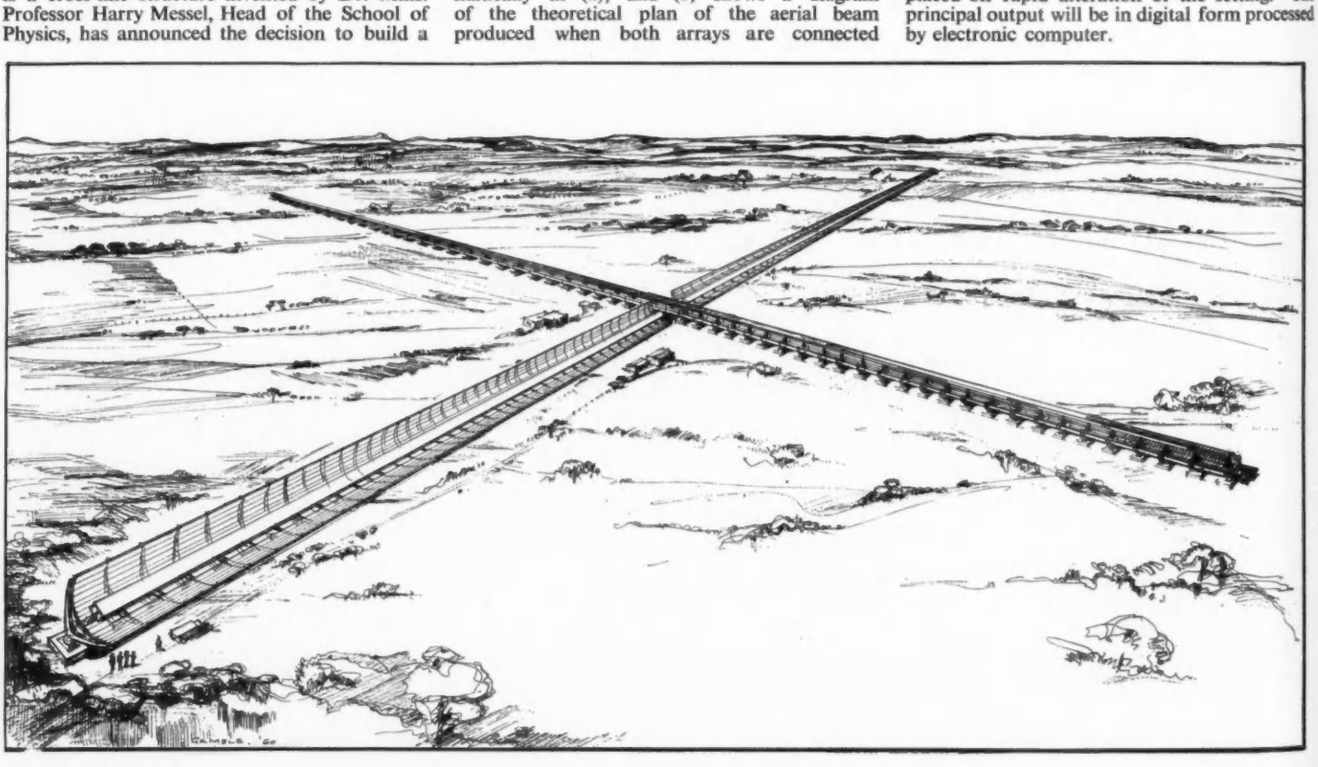


(a) Plan view of dipoles in cross arrangement. (b) Plan view of idealised response of cross arrangement

placed end-to-end and the north-south arm has parallel dipoles. The layout is shown schematically in (*a*), and (*b*) shows a diagram of the theoretical plan of the aerial beam produced when both arrays are connected together in one phase. Where the arrays intersect there is an increased response due to reception from the same source in both arrays, but the total solid angle over which reception occurs is very large and this aerial diagram is unsatisfactory. However, if the arrays are connected in antiphase, the response from the individual arms will be unaffected, but there will be no response from the central over-lapping region. If, therefore, the connections between the aerials are switched rapidly between the in-phase and anti-phase conditions, a source in the solid angle common to both beams will deliver a modulated signal at the switching frequency, and a signal received by either aerial alone will have no modulation. It is this modulated signal which is the basis for analysing the pencil beam determined by the maximum dimension of each array.

It is intended to operate at two different wavelengths, near 75cm and near 3cm. The shorter wavelength is the basic one. The beam width will be less than three minutes of arc with the planned size of 1 mile.

The beam is varied in declination about 45 deg. either side of the mean normal at 34 deg. S., by changing the phases of the dipole currents in the north-south array, and by mechanical tilting of the east-west arm. Emphasis is being placed on rapid alteration of the setting. The principal output will be in digital form processed by electronic computer.



CONTINENTAL AFFAIRS

by Our Continental Editor

Twenty-Fourth Salon International de l'Aéronautique

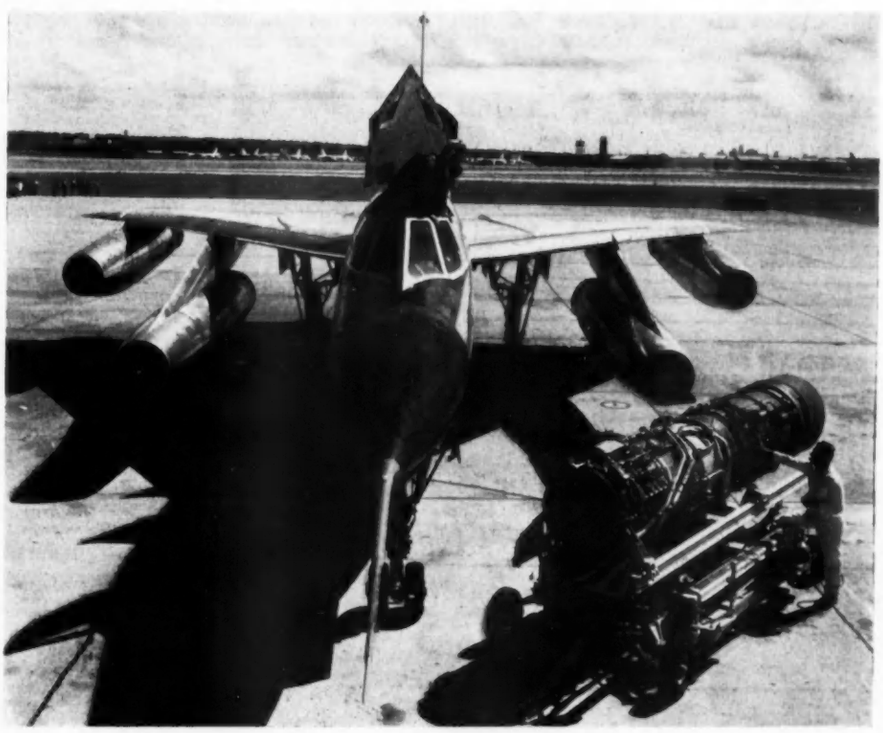
The biennial exhibition of the Union Syndicale des Industries Aéronautiques opened at the Le Bourget airport, Paris, last Friday, and continues until the coming Sunday. The exhibition is international, and there were demonstrated in flight machines from seven European countries, Canada and the United States of America. On the opening day of the show a record for the flight from New York to Paris was set up by a Convair "Hustler" with an average of over 1000 m.p.h.

THE 1961 Salon International de l'Aéronautique is the twenty-fourth in the series which commenced in 1909 with a "Salon international de la Locomotion Aérienne." This year's show includes exhibitions, from sixteen countries, numbering nearly 300, and the facilities include a basin of water 2500 square feet in area for the demonstration of amphibious V.T.O.L. aircraft, which are at present helicopters exclusively.

On the day the Salon opened a Convair "Hustler" B-58 medium bomber flew in from Fort Worth, Texas, establishing new records from both Washington and New York to Paris. The aircraft refuelled in flight three times; the tanks were filled only after take-off, and refuelling was carried out twice in the record-setting distance. Over the United States the machine did not exceed Mach 1, but after leaving New York reheat was used and a speed of about 1300 m.p.h. maintained. A course rather longer than the great circle (3600 sea miles from New York) was followed, since the 500 m.p.h. KC-135 tankers were confined to the same altitudes as the civil traffic over the Atlantic. The date of the flight was, of course, predetermined, and it turned out that the winds were of rather little assistance, perhaps five to six minutes; it is clear that this aircraft could, on the return journey, arrive in the United States at a considerably earlier hour than it left Europe.

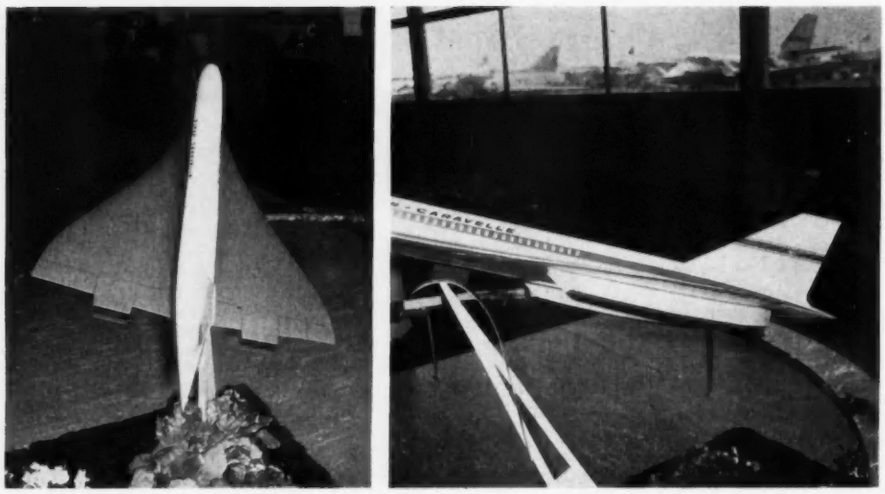
This flight brought up to eight the world speed records captured by B-58 aircraft this year; the "Hustler" holds the 1000km closed-circuit records with zero, 1-tonne, and 2-tonne payloads at 1284·73 m.p.h. and the 2000km closed-circuit records with zero, 1-tonne and 2-tonne payloads at 1061·8 m.p.h. Earlier this month, a B-58 became the first aircraft to fly 1000km in half-an-hour, and thereby qualified its crew to take possession of the Blériot Trophy; the flight, beginning and ending at Edwards Air Force Base, California, averaged 1302·04 m.p.h. for 30 min. 43 sec. On Saturday last the 1200 lb Blériot Trophy, which was instituted in 1930, was presented to the Strategic Air Command crew by Madame Louis Blériot and her son Jean. While to sustain 2000 km.p.h. for so long is a new achievement, it was remarkable that Convair was but one of eight manufacturers with Mach 2 aircraft on display, there being present also the Dassault "Mirage III," the Lockheed "Starfighter" F-104G, the Macdonnell "Phantom" F4H, the Nord "Griffon," the North American "Vigilante" A3J, the Northrop "Talon" T-38, and the Republic "Thunderchief" F-105. Such an environment was well suited to the appearance in model form of what will almost certainly be the first supersonic civil transport designed as such, the Sud "Super Caravelle." This pioneering design, is, like the "Caravelle" before it, intended for the rather less than medium length stages on which so much of the revenue is reaped, and is, as our photographs show, of a configuration widely favoured for flight at little more than Mach 2; however, the wing is virtually without camber, and apparently no effort has been made to distribute the lift to give minimum drag. The aspect ratio is not extreme, and the pilot's cabin, while designed for a deeper field of view than that of the "Caravelle," is apparently not unconventional. One noteworthy feature is that the nacelles, which not surprisingly are located in the high pressure field under the wing and well aft, are built directly on to the structure (the engines are too large to be termed "buried"); it is interesting that this manufacturer, whose experience of podded power plant is particularly long, should have chosen to discard such advantages as the ability to test complete installations on the ground, but possibly the greater simplicity of variable-geometry intakes and nozzles in a two-dimensional arrangement was preferred.

It remains the case, however, that much interest is taken in the rear-engine configuration, particularly using four engines of high thrust/weight ratio, and we therefore took the opportunity to fly in "Caravelle" No. 42, the "Santa Maria" of the General Electric Company, which is acting as a prototype for the "Caravelle VII" with CJ-805-23 ducted fan engines. The "Santa Maria" has an "AiResearch" gas turbine auxiliary power plant mounted in the extreme tail, rendering it independent of ground support equipment for starting and cabin conditioning, but this engine has a loud shrill noise and so the passengers were embarked at the front entrance. While taxying, the main engines were clearly audible in the cabin; it was noticeable that turns were made distinctly slowly, because asymmetrical thrust was available. The acceleration when the brakes were released was remarkably high—each engine has a standard thrust of 16,100 lb—and only twenty-five seconds were needed to reach 125 knots when rotation initiated an impressively steep climb. In flight, the forward cabin, which extends back to the leading edge, was virtually noiseless, the hiss of the ventilation nozzles seeming to be the main source of sound. Above the wing, the cabin was filled with engine noise, but both objective measurements and subjective experience showed that speech interference was low. From the trailing edge back vibration was present at and above cruising thrust, and noise levels were aggravated by resonance in the light fittings; the auxiliary power unit seemed also to be audible as a high-pitched whine—in short, the presence of powerful engines on the fuselage was obvious. On this prototype, the engines were being synchronised manually, and at each change of speed a heavy beat occurred for a period of the order of two seconds. At landing, reverse thrust was demonstrated; although only 38 per cent of the forward thrust is available—without reverse thrust, only 3600ft is needed at the maximum landing weight—a significant but smooth acceleration was evident when the engines were opened up. The "Caravelle VII,"



The Convair "Hustler" B-58 has established (subject to confirmation) eight world speed records this year; on the opening day of the Salon one crossed the Atlantic at an average speed of 1080 m.p.h.

CONTINENTAL AFFAIRS *(Continued)*



A model of the Sud " Super-Caravelle " supersonic airliner, showing the Ogee plan form, the thin uncambered wing and the two-dimensional intakes

it may here be remarked, will differ from the " Caravelle III " in other respects than having ducted fan engines ; the windows will be higher in the cabin wall (at present any attempt to peer out brings the passenger's head in contact with the pelmet) the visibility from the cockpit will be improved (the early marks of " Caravelle " have a nose modelled on that of a D.H. 106 " Comet "), an extra row of seats and an integral stair for the front entrance will be added, and if desired a resonator-type silencer will be fitted, although the " Santa Maria," which is externally the quietest jet airliner flying at present, is well below the Port of New York Authority requirements (107·6 PNdb at 1000ft, 1¼ miles from start of take-off ; 111·7 PNdb at 400ft and 1·8 miles from threshold on approach : with resonator these figures would drop to 106 PNdb.)

Another aircraft which, while not new, is not known in Europe is the Lockheed " Hercules " BLC-130. This largest of S.T.O.L. aircraft flew in to Paris after performing a demonstration in England ; in the S.T.O.L. mode (i.e. 500ft ground run) it can deliver a 35,000 lb payload and fly out again with fuel for a further 500 nautical miles. The boundary layer control system uses 50 lb per second of air, delivered at 57 lb per square inch by a pair of Allison T-56 engines with compressors in place of their airscrew reduction gears, to suppress separation at the hinge lines of flaps, ailerons, elevators and rudder. To simplify the installation, the area-increasing flaps of the C-130 were replaced by plain flaps, while 30 deg. of aileron drop can be used without loss of control effectiveness. The minimum flying speed is of course very much reduced, while the high profile drag of the " Hercules " tends in any case to give a low minimum power speed, so that it is necessary not only to blow continuously over both sides of the tail surfaces, but the rudder chord has been increased about 40 per cent ; the boundary layer control has allowed the maximum deflections of all control surfaces to be doubled. The ducting for all the nozzles is common and fed from both compressors, and flight at less than 60 knots has been demonstrated with only one compressor running.

The BLC-130 is merely a prototype, the performance of which suffers from the drag and weight penalties of the two engines used only to give S.T.O.L. performance. Engines well adopted to this application, do not, according to Lockheed, exist, presumably because auxiliary power units designed for air bleed were designed mainly for engine starting and an excessive number would be needed for the mass flow involved, while the one engine which might be expected to allow bleeding of about 10 lb to 12 lb per second, the BE-25, of course never

The first object to be recovered from an orbit without impacting upon the earth, the capsule of " Discoverer IX "

passed the prototype stage. It has been estimated that a Rolls-Royce " Tyne " with an auxiliary compressor, like the power plant proposed for the " Rotodyne," would prove suitable, and because of the way the specification is drawn up,

(Left)—A full-size model of the proposed " Seacat II," which will attain supersonic speeds (Right)—The " Red Top," a missile derived from and resembling " Firestreak," but with a marked increase in wing area

Component parts of the Short " Seacat " ship-to-air command guided missile, showing the four nozzles of the solid propellant motor and the four hydraulic motors varying the incidence of the wings

craft. The Mk. II is stated to use much of the Mk. I equipment ; however, it would seem that with the supersonic vehicle the effectiveness of the guidance that can be commanded in flight will be reduced and the influence of the heading at launch will be enhanced, so that the fact that the launcher is " slaved " to a control tower which is slewed manually may prove a disadvantage. There is still no information available to show to what extent the Short system of command guidance with a human operator active in the closed loop is effective in tactical conditions, when the enemy may be expected to realise that the weapons are manually aimed and to attempt to keep the layers from monitoring the targets uninterruptedly.

On the same stand a dismantled " Seacat " was displayed. It could be seen that the square body houses a motor with four nozzles, and that, as might be expected, the four wings are pivoted by hydraulic motors controlled by electrically operated valves. The hydraulic fluid is fed through a sintered metal filter forward from the propulsion section, and it appears that the hydraulic system may be a simple non-return circuit energised by the pressure in the main motor combustion chamber ; such a system might well be adequate for a short range missile needing only limited powers of manoeuvre, and would avoid the complication of motors expanding the hot and heavily contaminated gases exhausted from the solid charge.

There also appeared for the first time the D.H. " Red Top," an air-to-air missile closely resembling a " Firestreak " but with aerodynamic surfaces of increased area and revised outline. (It will be recalled that the " Fireflash " also appeared in a high-altitude form with increased wing area, but was not in fact produced). Another minor difference is that bulges appear around the leading edge wing roots, one of them housing the safe/arm switch. These bulges do not run back to the tail ; the " Red Top," like the later " Firestreak " production, has the flying control runs inside the envelope. There is no sign of any stadiametric rangefinder, suggesting that De Havillands may have acquired a radar proximity detector by collaboration with Engins Matra. Little information can be given about " Red Top " ; apparently it has been evaluated against realistic targets to an even lesser extent than " Firestreak."

Preparing to launch a " Blue Water ": the bombardier will use the theodolite telescope to monitor the inertial navigator through the window (protected by a flap) inside the white circle. Notice the short armoured hoses for the external power supplies ; only after changing to internal power does the launcher raise the missile towards the bearing of the target

with the take-off weight less rather than greater than the landing weight, this appears feasible. However, the Lockheed production capacity is fully committed with the urgently needed C-130B and subsequently the C-141 of longer range and higher speed, so that the realisation of this militarily valuable potential is not immediately in prospect.

In the static exhibition there was to be seen another Lockheed product with an even more distinguished history, the capsule of " Discoverer XIV," the first object ever to be recovered from an orbit about the earth without having impacted on the surface ; in this case the re-entry was achieved at the time and place commanded and while the capsule was descending by parachute it was grappled by a Fairchild " Boxcar " C-119 and hauled aboard. The vehicle from which the capsule was separated, the Lockheed " Agena," has been described as the first true space vehicle (at least originating from this planet) since it has the capability of stopping and restarting its Bell " Hustler " engine and of stabilising itself with respect to space or to Earth ; it is called after a bright star near the Southern Cross towards which it is launched when achieving a polar orbit from the Pacific Missile Range. Our photograph shows the highly convex heat sink of the re-entry body, with behind it some of the equipment which survived re-entry ; the instrumentation and records have been removed.

The related fields of space flight and of missiles were strongly represented at the Salon, and upper atmosphere research rockets in particular were numerous. Among the British exhibits not previously seen was a model of a proposed Mk. II " Seacat " which will have a supersonic performance, thus enabling it to be launched at a later stage in the approach of the enemy air-

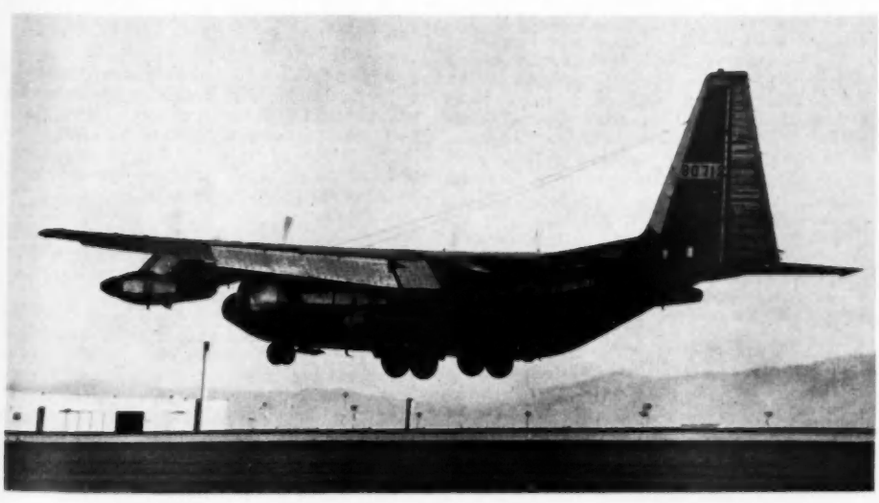
This was virtually the only display of missiles in which emphasis was placed upon infra-red guidance, the " Falcon " given prominence, for instance, being the GAR-II with semi-active homing. Because of the major tactical advantage possessed by a collision course weapon, the development of radar guidance has been carried to an advanced stage, as is demonstrated by the following quotation from the publicity material for the Matra 511, a " twist-and-steer canard " with a 25 kg warhead and a total weight of 180 kg :

Performance :

Vitesse en fin de combustion	Mach 1·8
Domaine d'emploi	3000 à 18000m/mer
Portée autodirecteur	8km

Collision course capability is in fact claimed for the improved guidance of the new Matra 530 cruciform delta, homing on the wake of the target, but radar guidance is available for use in rain and cloud, even down to ground level.

At the Salon there made its first public appearance the English Electric " Blue Water " tactical bombardment missile. The vehicle is simple in appearance ; advantage has been taken of the high initial acceleration available with a solid propellant motor to dispense with any attitude control at speeds too low for the aerodynamic surfaces to be effective, although since in the absence of a separate booster the initial acceleration must be held down to limit the loads at later stages, this does involve launching at a



The Lockheed " Hercules " BLC-130 demonstrated its S.T.O.L. ability, which is achieved largely by blowing over the hinge of the flaps, which are deflected to 60 deg. in the take-off configuration

CONTINENTAL AFFAIRS *(continued)*

The penultimate stage in launching the "Blue Water"

steep angle. Since this vehicle was designed from the start to use solid propellants, the moving surfaces are no longer at the tail but amidships ; since there will be close to zero *g* transverse to the trajectory, this cruciform of wings is only small.

The weapon has inertial guidance with neither homing nor command facilities, and is therefore fired in the manner of a howitzer, from a point whose position in space is known at some other position in space. The inertial guidance, which is based on Honeywell integrating gyroscopes built under licence in England, requires to know the range and, in principle, the latitude and difference in altitude of the target, rendered into the form of a relationship between apparent acceleration and elapsed time. This information is prepared in a computer that is carried in a l.w.b. Land-Rover, which will serve a number of missiles.

The initial stage in preparing to launch the weapon is to survey (locate) accurately the firing site ; its co-ordinates are set into the ground computer. When it is intended to use the site a theodolite is set up thereon and oriented with respect to North.

Immediately target information is received "Take Post" is ordered and the firing troop double to their duties. The target co-ordinates are set into the ground computer which immediately produces a rough bearing to the target. The reciprocal of this bearing is telephoned to the theodolite operator who sets it on his theodolite. Under his direction marker posts are set out on this bearing as a guide for the launcher driver. The launcher then moves out from under cover into the launching position.

By now the ground computer has worked out an accurate target bearing and the theodolite telescope is set at 90 deg. to this. The launcher is driven into position, the driver aligning himself with the marker posts, so positioning the launcher with its rear towards the target. Under the direction of the theodolite operator the launcher is halted opposite the theodolite and a remote control box is laid out. The rear of the launcher is jacked up and levelled transversely.

The computer vehicle drives up alongside the launcher and is connected to it by a multicore cable. The computed flight information is then quickly transferred to the missile and stored for flight use. The travelling clamps on the missile are released, the stabilised platform of the inertial guidance system is unlocked and the firing cable laid out. The firing circuits are checked and the igniter fitted to the rear of the motor. Meanwhile the theodolite operator, looking through the theodolite into a window in the skin of the missile, uses the remote control box switches to align the stabilised platform accurately and null its drift.

With two minutes to go before firing, the remote control box is stowed and the theodolite packed up. The firing troop, except the officer and sergeant, clear the firing area. The officer operates the warhead safety switch and the sergeant arms firing circuits, and then both double off to the firing box laid out fifty yards or so away. The officer operates the firing switch to energise the missile's own power supplies. When the missile has changed from external to internal power supplies the launcher boom automatically elevates to the firing position. The firing switch is then operated a second time and the missile takes-off.

The time from the receipt of target co-ordinates to the missile firing is ten minutes. After firing, the launcher boom is lowered, jacks placed in the travelling position, firing box stowed and the site cleared within two minutes. A change in target azimuth requires the launcher to be moved and a change in range involves connecting up the computer vehicle, so it can be seen that the system is not suited for use against targets of opportunity ; it is presumably envisaged that gunfire or a guided missile such as "Lacrosse" would be used in support of troops, and "Blue Water" merely against targets justifying nuclear warheads.

British Trade Fair in Moscow

A fortnight ago the British Trade Fair in Moscow was opened. The official ceremony was attended by the Chairman of the Council of Ministers of the U.S.S.R., Mr. N. S. Krushchev, and seventeen other leading members of the Soviet Government, as well as by British personalities connected with the Fair, and 2800 other guests. The British Trade Fair certainly forms the principal current attraction for the people of Moscow.

The event was widely advertised in Russia six months ago when tickets were put on sale they were practically all taken up, and now are very difficult to obtain. Probable attendance has been estimated at over 1,000,000. On the Sunday following the opening when about 110,000 people sought admission, congestion in the halls grew to such a pitch that the gates had to be closed temporarily until the crowd had thinned out again.

The Fair remains open for twelve hours per day, from 9 a.m. until 9 p.m., Saturdays and Sundays included, until June 4. The morning period from 9 a.m. until 10.30 a.m. is reserved for officials, technical people from the Regional Economic Councils and the Trade Organisations, as well as the Press. An information centre is in operation for their benefit, where trade information and interpreter-guides are available.

It was envisaged that people not only from the Moscow region but from all parts of the country as well as from other parts of Eastern Europe, would take the opportunity of seeing something of the capabilities of British industry, and to a large extent this hope appears to have been realised.

Reactions to the exhibits on the whole seem to be very favourable. This shows that the great care which has been taken to select only exhibits which were really considered suitable for the Russian market has achieved its object.

The cars on show such as the Jaguar saloon, the new Triumph "Herald" estate car, and the various conversions of the "Atlas Major" van developed for special overseas requirements are always ringed by spectators standing several ranks deep.

Interest in things technical shown by all ages and by both sexes is very striking. What has caused some surprise and comment among the British exhibitors are the large numbers of technically trained and educated women. Examples of this phenomenon which the persons —all males—who reported it to the present writer appear to have found slightly unsettling, are the cases of the two women mining engineers who expertly evaluated a certain design of hydraulic pit prop, and the shy young thing who turned out to be an electronics expert in charge of a department and proved her professional status by the penetrating nature of her questions.

Technicians among the visitors appear impressed by the general high quality of the exhibits. Particular interest is being aroused by equipment connected with control and automation. British instruments and electronic equipment have been highly praised, e.g. air traffic control equipment has been commented on in this sense by a high official of the "Aeroflot" Soviet Airlines Arctic service. Similarly much interest is being shown in the De Havilland "Anatrol" computer.

While the general tenor is thus favourable, at least one distinguished Russian visitor connected with the steel industry has expressed the criticism that the designs on show were not always the latest ones available. Others have complained that certain kinds of equipment they themselves were interested in were not being shown although the makers were amongst the exhibitors. Disappointments of this sort are of course unavoidable in the nature of things as a show like the present one can never hope to present more than a fraction of our production.

Nevertheless, that such sentiments should be voiced at all really seems to bear out the impression of a general balance and completeness which has been achieved. That this impression is not a mere illusion is shown by the fact that over 2500 tons of exhibits are on view here on the 180 stands or open-air sites.

Showing their products are 725 participating companies, many individually, but others in groups organised by a trade association or by one member of the group. Included in the presentations are 103 technical films.

Synthetic Paper

After several years, collaboration between the research department of Société de la Viscose Suisse at Emmensbrücke, and the Zurich paper-mill, Papierfabrik an der Sihl, has led to the production on a commercial scale of paper based on synthetic fibres. Because of the expensiveness of the initial product, the cost per square foot of "Syntosil," as the new paper is called, is comparatively high and of the order of that of the lowest priced textiles.

There have been many attempts in the past to use synthetic textile fibres for the manufacture of paper. Natural fibres, whether derived from textiles (rags) or wood pulp, as the result of a suitable grinding process acquire the property of forming a strong, solid fleece. The structure of synthetic fibres is smoother and more compact, and they do not form a fleece in this way. However, a chemical process has now been found that will enable these fibres to build up a fleece which can be manufactured in quantity on a paper machine. Various weights and colours are now stated to be in production.

While "Syntosil," like conventional paper, will take writing, painting, and printing, its strength and resistance, both mechanically and chemically, render it superior in a number of applications where these factors outstrip the higher price. Thus, for instance, normal cellulose paper can be folded about 1000 times in both directions before it breaks; the synthetic paper can withstand 20,000 double foldings in the transverse direction, and as much as 100,000 in the longitudinal direction. The great strength of the material has been vividly demonstrated by a test in which a small saloon car was hoisted by a crane by means of a sheet of "Syntosil" approximately 18in wide twisted into a rope. Resistance to tearing is even greater when the paper is wet, being about twice the dry value. Impact resistance is about 40 per cent greater in the wet state. Resistance to chemical action is also claimed to be excellent. Thus, treatment with 12 per cent caustic soda or 4 per cent hydrochloric acid solution at 20 deg. Cent. for forty-eight hours shows hardly any effect; tensile and tearing strength in fact increase by as much as one-third.

A most useful property is the resistance to soiling. Moreover, the material can be washed many times, a procedure which raises tearing strength, and substantially increases abrasion resistance. In a test, it is stated, samples were washed ten times in a solution containing 5 grams of soap per litre at 60 deg. Cent.; the tearing strength rose by 46 per cent and the resistance to abrasion by 560 per cent. Throughout, ink and colour stability are said to have been perfectly preserved.

Our illustration shows a map which has been soiled being cleaned by vigorous scrubbing with brush and cleanser powder. After a few minutes this restores its original appearance.

These outstanding properties, it is claimed, make synthetic paper particularly suitable for such things as maps, banknotes, season tickets, punched cards and similar applications.

[Reply Card No. 1011]

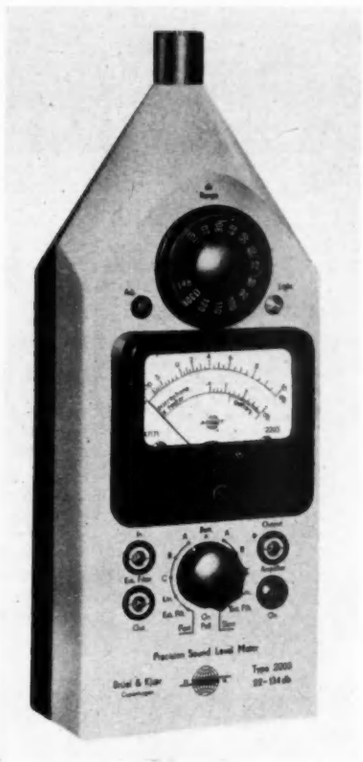
A heavily soiled map printed on synthetic paper being restored by scrubbing with cleanser

Precise Sound Meter

A precise instrument for the measurement of sound levels has been placed on the market by Bruel & Kjaer, Naerum, Denmark (agent : B. and K. Laboratories, Ltd., 4, Tilney Street, London, W.1.). The instrument, which is shown in the accompanying illustration, is transistorised, portable and battery-operated, and is built to full proposed. I.E.C. standards. Equipped with a precision condenser microphone, the instrument gives a direct scale reading from 22dB to 134dB to an accuracy of ±1dB and the linear frequency characteristic ranges from 20 c/s to 15 kc/s. An overall amplification of 110dB gives full deflection on the meter for an input voltage of 10μV, and by applying extensive negative feedback throughout, the stable operation of the amplifier is ensured. A built-in stabilised control generator gives a ready check on the amplification. Between the first and second stages of the amplifier the three I.E.C. weighting networks for precision sound level meters are included. The quasi-R.M.S. rectifier circuit fulfils the I.E.C. standard requirements. By connecting external 1/3 and 1/1 octave filters, the meter can be rapidly converted into a frequency analyser, and when a permanent record is required, a recorder can be connected to its output. By substituting a microphone cartridge with an adaptor it can be converted to a voltage and vibration amplifier, and by connecting an accelerometer to the input, vibration measurements can readily be made.

In order to facilitate the taking of measurements in dim and badly lit places, the meter scale can be lit, and when in operation an intermittent pilot light periodically flashes, indicating that the power supply is on. The instrument can be supplied with a solid leather carrying case.

[Reply Card No. 1008]



Precise sound meter

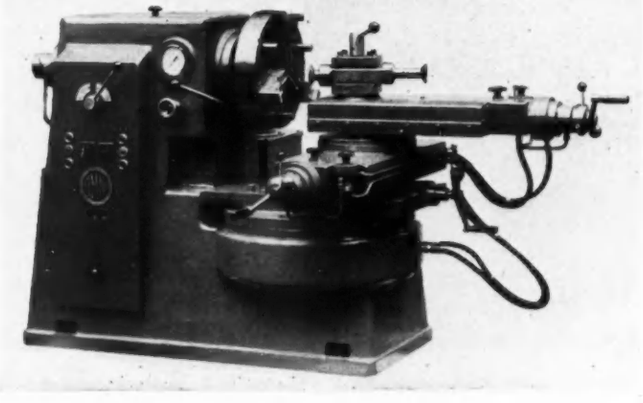
Wheel Dressing Lathe

Our illustration shows a hydraulically operated wheel dressing lathe made by A. Mengeringhausen Nachf. K.G., Iserlohn (Westphalia), P.O. Box 258. Agent : IMPAG (London), Ltd., 10, Lloyds Avenue, London, E.C.3. The machine is designed for trueing, shaping, and drilling ceramic-bonded grinding wheels. It is powered by a pole-changing motor driving the headstock spindle through vee-belts. A single-lever control starts and stops the motor, and applies the brake after switching off. The tool post permits the simultaneous clamping of a trueing tool for external operation and of another one for drilling and internal operations. Spur gear index plates installed in a dustproof manner enable the tools to be set rapidly in one of ninety-six different positions. The top slide is swivel mounted on the cross slide, with the slides being fitted with roller bearings.

The mechanical clamping parts of the dust-proof three-jaw chuck are actuated by a hydraulic cylinder mounted on the headstock spindle. Unvarying pressure is maintained nearly in full even if the oil supply pressure should fail. The chuck may be exchanged for a rapid-action clamping arbor which is operated by the same hydraulic drive.

Top and bottom slides of the compound rest are equipped with oil motors which drive the feed screw spindles. Overload slipping clutches protect the mechanism. A square end on the oil motor output shaft permits a hand crank to be fitted for operation by hand. All hydraulic equipment is supplied from a pump unit at the rear of the machine.

[Reply Card No. 1010]



Wheel dressing lathe with hydraulically-operated compound slide and hydraulic clamping of the workpiece in the chuck

THE AMERICAN SCENE

By Our American Editor

Centennial of the Massachusetts Institute of Technology

No. II—(*Continued from page* 890, *May* 26, 1961)

Courses at M.I.T.

THERE are to-day twenty-one academic departments at M.I.T., organised into five schools. Of these departments, sixteen award Bachelor of Science degrees, which require four years of study. The Department of Architecture offers a five-year undergraduate programme leading to the Bachelor in Architecture degree. The degree programmes are arranged in " Courses " according to major fields of study. Much flexibility is provided within these Courses by " options " and electives, and individual students find opportunity to pursue special interests as they work to meet the degree requirements.

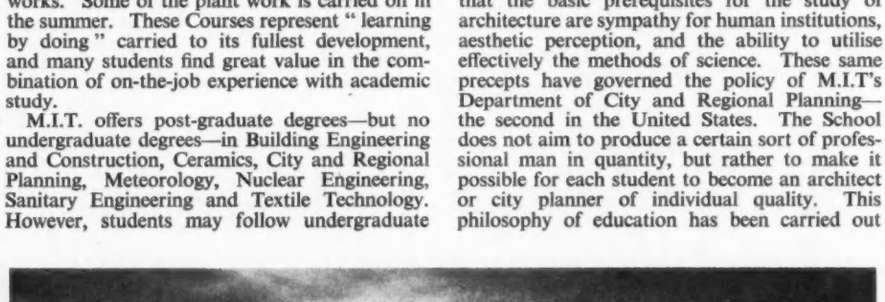
Among these options are the " Co-operative Courses," in which, as in the British sandwich system, a student's time, after his second year, is divided between academic work at M.I.T. and practical experience at leading industrial works. Some of the plant work is carried on in the summer. These Courses represent " learning by doing " carried to its fullest development, and many students find great value in the combination of on-the-job experience with academic study.

M.I.T. offers post-graduate degrees—but no undergraduate degrees—in Building Engineering and Construction, Ceramics, City and Regional Planning, Meteorology, Nuclear Engineering, Sanitary Engineering and Textile Technology. However, students may follow undergraduate programmes which give them excellent preparation for post-graduate study in any one of these fields. Many students enter M.I.T. with a decided preference for a particular field of study, but experience shows that a large number of these students later find another field to be more to their liking. Each student has an opportunity to indicate his choice of Course at the end of his first year, and he must do so by the end of his second year. If beyond this point in his career at M.I.T. a student finds from his own increasing knowledge of himself and of the things he is studying that he wishes to change his Course, he will almost always find that he can do so with little loss in time.

School of Architecture and Planning

As the first institution to organise and develop formal architectural education in the United States, M.I.T. has steadily held to the belief that the basic prerequisites for the study of architecture are sympathy for human institutions, aesthetic perception, and the ability to utilise effectively the methods of science. These same precepts have governed the policy of M.I.T's Department of City and Regional Planning—the second in the United States. The School does not aim to produce a certain sort of professional man in quantity, but rather to make it possible for each student to become an architect or city planner of individual quality. This philosophy of education has been carried out mainly by creating the kind of environment where different minds and talents may find stimulus, motivation, and a sense of direction.

Although the School does not underestimate the value of learning specific skills, it feels that a groundwork of real interest in ideas is far more important. Hence, it tries to give all students the aesthetic experience of the visual arts and at the same time introduce them to the methods and attitudes of engineering. It feels that particular stress should be laid on the importance of knowing the physical laws with which an architect must deal in performing his tasks, and it tries to show the importance of working in the team, not only with engineers but with others in the many fields of action in which architects are called upon to function. The School encourages students to develop both common sense and passion and within those two virtues to learn to search for facts, to understand techniques, to co-ordinate results, and finally to synthesise them in clear and creative expressions. It hopes thereby to give them the courage to be dissenters when necessary without relinquishing poise and restraint, so that inventiveness may at all times be motivated by logic and by the satisfaction of visual order rather than by the desire to be different.



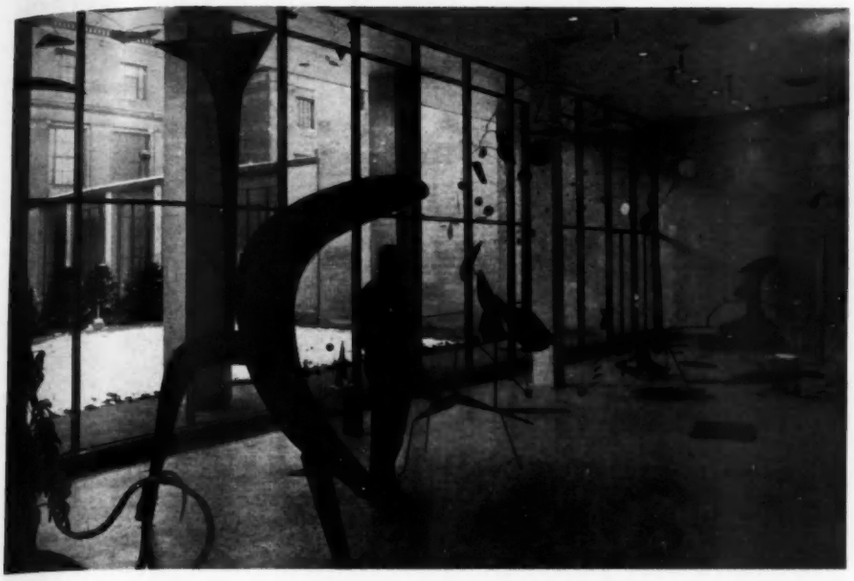
The Kresge auditorium and the M.I.T. chapel, both designed by Eero Saarinen

School of Engineering

It is the engineer who is bringing about the great revolution in technology. Largely by his efforts man has at last achieved the technical potential for the creation of a society free from want. Although engineers deal extensively with facts and scientific principles, they also must carry out their work as leaders of men. Their ultimate stature, therefore, often finds expression in those situations where judgment and wisdom weave the elements of scientific knowledge into the whole fabric of society. Accordingly, the educational plan at M.I.T. interlaces a sequence of studies in science, engineering, and the humanities with involvement in research, in a manner that embraces all the elements of a truly liberal education.

Among M.I.T's 25,000 engineering alumni are many who have become independent professional consultants, college or university professors, or entrepreneurs responsible for their own businesses. The majority of them, however, are either on the staffs of industries, where they perform technical work of a highly varied and challenging character, or are members or leaders of management in industry. As the impact of engineering in world affairs accelerates, M.I.T. engineers in ever-increasing numbers have the distinction of serving as advisers to Government on many important issues.

The various curricula within the School of Engineering are sufficiently general so that no student is confined to a narrow specialisation. In fact, specialised knowledge is now of such quantity and its application so sophisticated that it cannot be mastered in four, five, or even six years. Furthermore, the engineer and the scientist, working in concert, are setting such a pace in technological change that specialisation is often outmoded several times within the span of a professional lifetime. It is not enough merely to prepare an engineer to keep abreast of a particular contemporary technology. Accordingly, the goal of the School is to equip its students with an understanding of the basic sciences—mathematics, physics, and chemistry—and of the engineering of science; and to develop in them a versatility of mind and an ability to learn anew so that, as professional engineers, they will work at the frontiers of their field and bring forth new technologies, the very



The New Gallery of the Charles Hayden Memorial Library

nature of which may be virtually unknown during the period of their formal education.

The curriculum of the "freshman" or first year and about two-thirds of the curriculum of the "sophomore" or second year are, in effect, identical for all courses at M.I.T. The technical and professional subjects that lead to a major field begin only in the later years. Mature professional education finds its full expression in the post-graduate years. The student who decides early in his programme on the broad field of his major subject may enter a department at the beginning of the "sophomore" year. In most instances this student may elect, for about one-third of his "sophomore" studies, subjects that are a definite part of his major programme. On the other hand, the student who wishes to postpone his choice of department until the end of the "sophomore" year need not necessarily delay his graduation beyond four years, because any sequence of elective subjects he chooses for the one-third of the "sophomore" year will be credited to his total degree requirements.

The Institute feels that the basis of choice among engineering fields should lie within—rather than outside—each student's mind and personality. When assessing the question of becoming identified with a particular engineering field during a period of study, a student is wise to choose the one which provides an immediate, potent source of motivation and inspiration rather than to attempt to foresee what his permanent area of professional activity may be. To find expression for one's gifts and to carry one's education as far as those gifts justify is the essential purpose of higher education, in the opinion of M.I.T.

The undergraduate programmes of all departments of the School of Engineering are built upon a strong scientific base to give knowledge of enduring value. Each programme leads to a wide range of choice of a career and serves as preparation for continued on-the-job study following graduation, or further formal graduate study in a broad spectrum of fields. A student may thus safely follow his own intuition with the conviction that his training will equip him for the unknown future, whatever the details of his professional career may be.

School of Humanities and Social Science

The School of Humanities and Social Science embraces the work of a faculty divided into three cross-disciplinary departments. The Department of Economics and Social Science includes the faculty interested in economics, political science, psychology, labour relations, and sociology; the Department of Humanities includes the faculty concerned with history, literature, music, and philosophy; the Department of Modern Languages numbers those whose interest is in modern languages, literature in foreign languages, comparative literature, and linguistics.

This faculty has three complementary missions. The School is in the first place responsible for much of the general education required of every undergraduate at M.I.T., regardless of his area of specialisation. In this role members of the faculty, mostly, though not all, drawn from the Department of Humanities, guide every "freshman" and "sophomore" through the common core curriculum in the humanities; later, all of the faculties of the School meet their share of juniors or seniors, as these upper class men are required to elect one field for concentrated study in the humanities and social sciences.

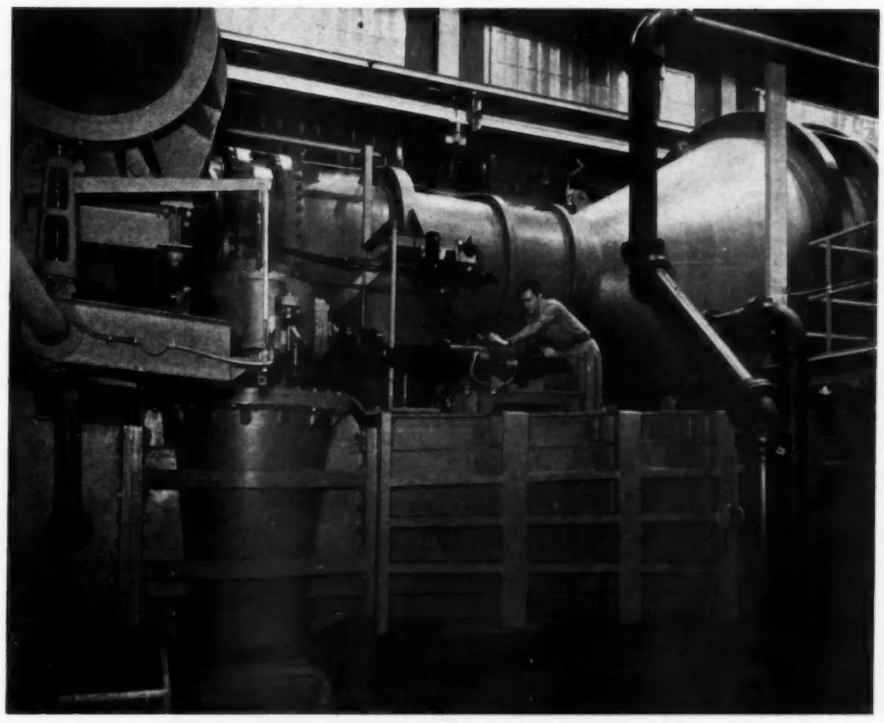
A second mission of the School involves offerings leading to the degree of Bachelor of Science. There are currently four such programmes, two in the Department of Economics and two in the Department of Humanities. These four degree programmes all require a second major subject either in some branch of science or in a branch of engineering. In this respect they differ in form from curricula in similar fields at other institutions. There are other differences of perhaps greater import. M.I.T., as an institution polarised around science and engineering, accepts the view that science and engineering are important elements in all modern life, that they are to be embraced rather than to be feared. Thus these degree offerings in the School of Humanities and Social Science require the same rigour in science and engineering—though not the depth of accomplishment—that is required of scientists and engineers; the programmes include these subjects as a fundamental part of contemporary culture. Far from regarding the scientific study as antithetical to the humanistic, they recognise the essential unity of serious study in any area. Thus these programmes may be particularly well fitted to prepare the right kind of young man or woman for living in the modern world.

The student whose formal education is completed with his four-year degree is likely to find that the preparation for modern life afforded by these courses in economics, political science. or humanities is unique and effective; if he intends to continue to higher degrees, he will find that he is well prepared for study in a law school, medical school, or graduate school of industrial management; he will also find it possible to continue at once in post-graduate work in either of the two major subjects he has carried as an undergraduate. Thus the curriculum is an unusually flexible and open-ended one.

The extent of the post-graduate work and research is perhaps the feature which most distinguishes the School of Humanities and Social Science at M.I.T. from those to be found in other technological institutions. The extent to which the members of this faculty are in close contact with the faculties of science and engineering is perhaps what most distinguishes it from those of non-technological institutions.

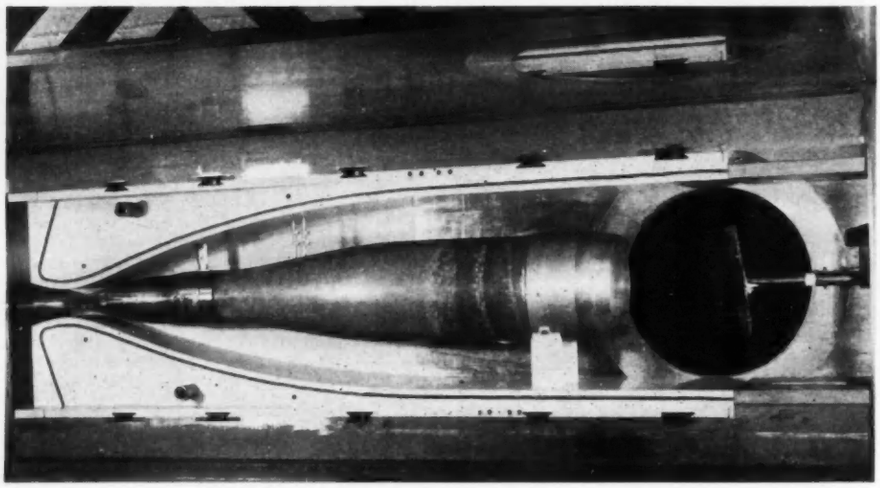
School of Industrial Management

The preparation of managers has long been an appropriate and significant responsibility for M.I.T. Management is concerned with the action that effectively integrates the technological, economic, and human resources to meet the goals of an organisation. As the "oldest of the arts and the newest of the professions" management is an applied field, and the manager leans heavily on the contributions of the social and physical sciences and the humanities in meeting the problems of industry, community and Government. He makes his decisions,



Test section of the wind tunnel in the Naval supersonic laboratory

THE AMERICAN SCENE *(Continued)*



Hypersonic nozzle installed in the supersonic laboratory wind tunnel to double its velocity to Mach 7

moreover, in a society characterised by increasingly complex technology. For the man who seeks to master the practice of management and for the researcher who wants to understand it better, the Institute provides a focus of these factors and frameworks.

The concept of combining scientific and engineering education with a preparation for management at M.I.T. dates formally to 1914 with the founding of a four-year undergraduate Course. In 1952, the School of Industrial Management was established by a grant of the Alfred P. Sloan Foundation. To-day, unique among schools preparing men for management, the School has a student body which includes four levels of students who work together, each benefiting from associations with the others ; the undergraduates, seeing management problems for the first time while following an intensive parallel programme in one field of science or engineering ; the post-graduate students, including both master's and doctoral candidates in industrial management ; participants in the Sloan Fellowship Programme for young executives about to assume major responsibilities ; and members of the Programme for Senior Executives, who have advanced experience and responsibilities. For all these groups, the general approach to education for management in the School of Industrial Management remains one of emphasis on a firm grasp of fundamental frameworks of analysis, a breadth of view, and a habit of continued learning that bring a confident and competent approach to problems yet unsolved in industry. Three points indicate the basis of this approach.

First emphasis is put on study of the role of man himself. Here is included the full sweep of the organisational relationships between men and groups in achieving their objectives. Here also is the study in depth of the environment within which business must progress. The economy and its complex effects on the individual firm, the social and political world, and, indeed, a sense of the history of change and progress must be part of the manager's understanding.

Second, a strong point in the School's approach to managerial education has always been in the measurement and quantitative analysis of management problems. While management is an art, it is an art that is immensely and importantly influenced by the application of the methods of science to its many complex, interrelated elements. The student who is to be the senior manager of the future must be well grounded in the mathematical analyses of operations, in the methods of management decision-making made possible by high-speed computers, and in the more rigorous control applications of accounting, statistics, and forecasting.

Third is the attack on practical problems which represent a complex mixture of several variables. These are traditionally represented under such headings as marketing, production, and finance. In this functional area approach, theory is applied to practical studies of problems now existing and constantly arising in a world of action.

School of Science

The School of Science at M.I.T. offers a broad training and its teaching and research activities may be classified, broadly speaking, into four fields—physical sciences, life sciences, earth sciences, and mathematics. The physical sciences are concerned with the structure and interaction of matter and energy. Particularly active in this category at present are studies of atomic nuclei, of elementary particles, and of the great concentrations of energy which can be released in nuclear reactions ; of electron physics and the incredibly varied ways in which the motion of this lightest of the particles can be used ; the structures of atoms and molecules and of the electric and magnetic interaction of their various parts ; the structures of liquids and solids, of metals, of insulators, of semiconductors, and the analysis and building up of molecular assemblages of increasing complexity.

The life sciences cover a very broad field. The most fundamental division is concerned with molecular biology and the chemistry of the molecules found in living cells. These molecules occur in a wide variety of forms, from the simplest inorganic and organic types up to the most complex known, the protein molecules. The properties of these molecules, when gathered together, govern the structure and the energy-converting properties of living systems. In cellular biology the scientist studies the structure, function, and origin of whole cells. In systems biology he examines the combined effects of aggregates of similar cells whose co-ordinated action determines particular activities of an entire plant or animal. Finally, psychologists, sociologists, and ecologists study the input-output relationships of the whole organism. Teaching and research in all these fields and in the relations between them are carried out at M.I.T. in biology and related departments.

In the earth sciences a great variety of physical and chemical phenomena present themselves in complex systems that call for a penetrating application of the basic concepts of the physical sciences. Much of the field of classical physics, not related to the atom or its nucleus, was historically developed in the study of these earth science problems, and recent advances in the understanding of the earth's atmosphere, of weather prediction and control, and of the seas and oceans are continuations of this effect.

Mathematics plays an increasingly important role in all of science, and the mathematicians at the Institute are continuing their tradition of fruitful co-operation and progress in both pure and applied mathematical fields.

M.I.T. Computation Centre with electronic data processing machine

Solar-heated house with flat plate collectors and chemical heat storage

Excitation coils of an electron linear accelerator

Atoms for Peace Award

A special event during the Centennial was the presentation of the 1961 "Atoms for Peace" award to Sir John Cockcroft at the Kresge Auditorium on April 6. These awards grew out of a statement made by President Eisenhower in Geneva on July 20, 1955, when he called for renewed international effort in the harnessing of nuclear science to peaceful uses and concluded with the hope that "private business and professional men throughout the world will take an interest and provide an incentive in finding new ways that this new science can be used . . . for the benefit of mankind and not destruction." It was in response to this appeal that the Ford Motor Company Fund created the "Atoms for Peace" awards as a memorial to Henry Ford and Edsel Ford. The Fund authorised an appropriation of 1,000,000 dollars to be used at the rate of 100,000 dollars annually for ten years—for awards for outstanding contributions in this field. The awards are granted by a wholly independent scientific and educational corporation established for that purpose in November, 1955. The corporation is housed at the Massachusetts Institute of Technology and is managed by a Board of Trustees. Niels Bohr received the first award in 1957. The second went to George Charles de Hevesy, in 1958. The 1959 award was shared by Leo Szilard and Eugene P. Wigner, for their work on the first nuclear reactors. Alvin M. Weinberg and Walter H. Zinn shared the 1960 Award for their continuing contributions to nuclear reactor technology.

The recipient of the award in any year is determined by the Trustees from among the world's scientists, engineers, or others, who in their judgment has made the greatest contribution to the peaceful uses of atomic energy. This may be an individual, a group of individuals or even an organisation. The award is made without regard for nationality, politics, or any other consideration except the merit of the contribution. Anyone in the world is entitled to place in nomination the name of a person he believes to have made a significant contribution. The 1961 award is the fifth in the series and comprised a gold medallion and an honorarium of 75,000 dollars.

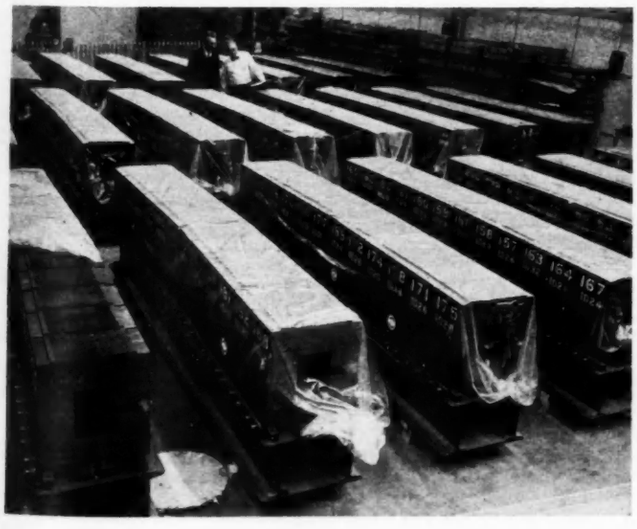
The following is the text of the citation presented to Sir John Cockcroft: "By your early work in the artificial disintegration of atomic nuclei, you helped to open the door to the atomic age; by your leadership in the establishment of the British Atomic Energy Research Establishment at Harwell as a centre for the study of peaceful uses for nuclear energy, you set an example for other nations to follow; by your active work in the programme for producing radioisotopes for research and development and in their distribution throughout the world, you made available to many nations a tool of great precision; by the establishment of a school for the study of isotopes at Harwell to which come students from all parts of the world, you created not only a teaching facility, but also an opportunity for scientists of different cultures and different tongues to live and work together, thus strengthening the bonds of world-wide understanding; by your support of the establishment of international centres for nuclear research, you have furthered the opportunities for international understanding and the sharing of knowledge; by your leadership, you have advanced the application of atomic power to peaceful use; by your insight and understanding, you have given to your colleagues and students a deeper awareness of the high goals of science in the service of man; may this medal, symbolising the 'Atoms for Peace' award, signify to all men the importance of your contributions 'for the benefit of mankind.'"

Macmillan Address

Over 5000 people filled the Rockwell Cage on Friday evening, April 7, to hear the principal centennial address by Mr. Harold Macmillan. In his opening remarks, the Prime Minister called the centenary an awe-inspiring event. "You were founded to teach 'the fundamental principles of positive science, with their leading applications to the industrial arts.' At that time no one could have foreseen the pre-eminent position which the Institute was destined to hold, not only in America but throughout the world. Both your method and your timing were right. In these years the application of scientific techniques to the methods of production, distribution, transport, and the communication of ideas has set the whole human race on the march. This process will go on until it has revolutionised the whole conduct of human life upon this planet and perhaps beyond. You follow the scientific method—by the ruthless logic of experiment. For you—as Thomas Huxley once said—the only tragedy is a hypothesis killed by a fact."

Turning to political themes, Mr. Macmillan emphasised that the time had come when it was necessary to "achieve some real unity of political purpose and method in the Western alliance. Three years ago your President and I declared for interdependence. To-day I say interdependence is not enough. We need unity—a wider unity, transcending traditional barriers; unity of purpose, of method, of organisation." Taking a realistic look at the state of the non-Communist world to-day, Mr. Macmillan said that over the last three years "we have broadly held our own, but have gained no ground." "The Communist bloc is stronger than it was," he said. "The uncommitted countries are more alarmed. The vital centre of the free world's resistance, our Western alliance, is no better organised, whether in the field of defence, economics or political relations."

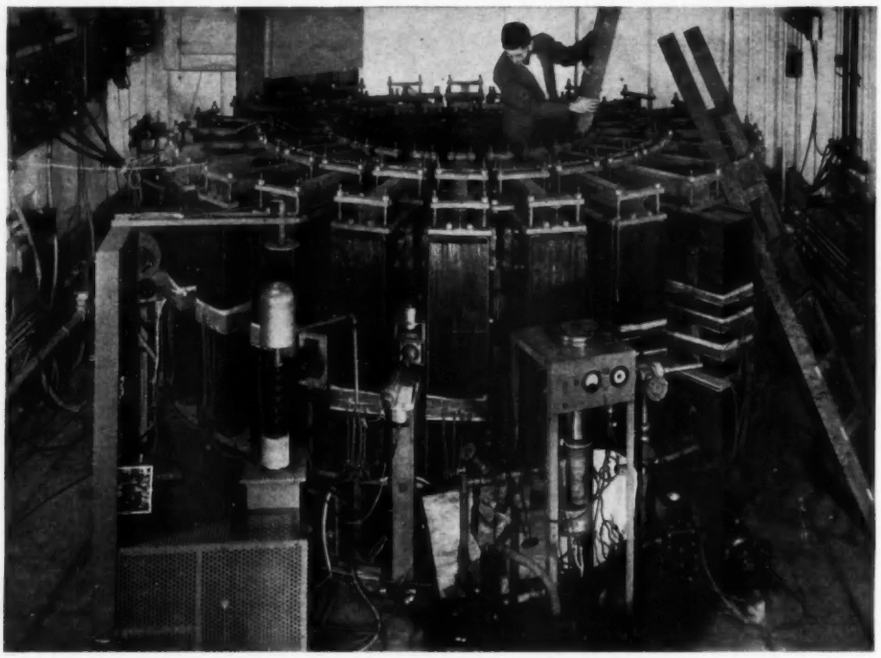
In these three fields, Mr. Macmillan gave these broad prescriptions. While maintaining a nuclear deterrent that is sufficient but not



Magnet sections prior to assembly in the 600 MeV Cambridge electron accelerator

Neutron therapy on malignant brain tumours in a room directly beneath the 1MW, M.I.T. reactor

THE AMERICAN SCENE *(continued)*



Electron synchrotron of 350 MeV maximum capacity

wastable, the Atlantic Western alliance must not neglect its conventional forces. The problem of "building a partnership" in the nuclear field must be faced. "Capitalism must expand or perish. The international trading arrangements evolved fifteen years ago under quite different conditions must be reorganised to achieve the largest possible area of free trade." The Western nations must concert their efforts to build up less developed areas. Finally, they must find ways to enlarge the non-Communist world's credit facilities for the expansion of trade and aid, and to control violent swings in the balance of payments of individual nations.

There is now, he conceded, a political rift in the alliance, a rift whose basis is economic division. This rift will expand and sooner or later "affect our military coherence and strength," if the economic division is permitted to persist, he asserted. So imperative did Mr. Macmillan regard the need to solve this economic rift that he went so far as to say that "the present struggle in the world is not primarily in the military sphere." "The real test," he warned, "will not be on the battlefield but in the market place."

Turning to the question of economic unity, Mr. Macmillan said that the most urgent problem "for us in Europe" was to bring together the six-member European Common Market and the seven-member European Free Trade Association. If the two trading groups could work out a comprehensive arrangement for Western Europe that would not be highly protective, the whole non-Communist world would benefit both economically and politically.

"These measures which I have suggested, and others which will become necessary, are the essential framework to buttress our endurance. If these things are not done, then our Western free idealist way will fall apart, and our disunity and weakness will discourage those very elements in the Soviet world which otherwise in time will work its salvation and our release. There is always change and movement in our lives. History does not stand still. Unless we work for greater unity we shall slide into division. The time is short. Let there be no delay."

British Participation

The British participants at the Centennial conferences included Sir Eric Ashby, Master of Clare College, Cambridge University; Mr. John F. Baker, Head of the Department of Engineering, Cambridge University; Mr. P. M. S. Blackett, Head of the Department of Physics, Imperial College of Science and Technology; Mr. Ritchie Calder; The Rt. Hon. The Lord Casey of Berwick; Sir John Cockcroft, Master of Churchill College, Cambridge University; Mr. William R. Hawthorne of the Engineering Laboratory, Cambridge University; Mr. Aldous L. Huxley; Sir Willis Jackson, Director of Research and Education, Associated Electrical Industries (Manchester), Ltd., also representing the senior British engineering institutions; the Rt. Hon. Philip Noel-Baker, M.P.; Mr. R. E. Peierls, Professor of Mathematical Physics, University of Birmingham; and Sir Solly Zuckerman, Professor of Anatomy, Medical School, University of Birmingham.

M.I.T. has been in existence for 100 years now. In some ways, it is an unique institution, reflecting in a diffuse manner the American civilisation as it has evolved out of the older civilisation of Europe into something new and different. Compared to universities like Oxford and Cambridge, which are nearly 700 year old. M.I.T is simply a budding youngster; its true greatness lies in future. Of some significance, certainly, is the fact that people speak of setting up an "M.I.T. of the Middle East" and other technological institutions "of the M.I.T. type." Possibly the direction of cultural flow has altered; M.I.T. has something about it that makes it an unique institution, one worthy of recontributing to the originating culture.

Unlike many other American colleges, M.I.T. is not a sentimental place; there are few plaques or historical sites on this campus, which in itself only dates from the great transfer of 1916. Few buildings are known by the names of their donors, or by the names of the men they were supposed to commemorate; they are known by numbers instead. Few students, and probably as few faculty members, know in any sort of detail the roots of the institution in which they spend a significant portion of their lives. The Centennial has marked something of a pause in the mad rush forward; it was a time when men were coming from all over the world to M.I.T. to stop and ask themselves about the world the Institute exists in. Whether anything of significance comes of the many conferences and panel discussions that have been going on remains unknown. Certainly it is demanding a great deal to expect that out of one brief week will come a major contribution to solving the problems of this complex world. If however, the men from the over thirty countries represented take back home with them some new understanding of each other, and of the problems the world faces, then the M.I.T. Centennial will have been a memorable event.

Nuclear Reactor for Auxiliary Power Generation

A SMALL prototype light-weight reactor to generate heat for the production of auxiliary power for space vehicles achieved criticality on April 3. The reactor weighed 200 lb without shielding and is fuelled with a uranium-zirconium hydride alloy. The reactor core is 13in high and 9in in diameter. The reactor is designated "SNAP 2 Development System (S2DS) Reactor" and is the second to be designed, constructed and operated for the U.S. Atomic Energy Commission by Atomics International, a division of North American Aviation, Incorporated, Canoga Park, California, as part of the development of a SNAP 2 reactor-electric power system for space vehicles.

The S2DS reactor core generates 50kW of heat. In an operational device the heat from the core would be transferred by a liquid sodium-potassium coolant to a boiler containing mercury. The mercury vapour would be directed into a miniature turbine for the generation of 3kW of electricity. The reactor will be mated to its power conversion unit for ground testing of the complete SNAP 2 system later this spring. After this testing programme has been completed,

Examining reflector of "S2DS" 50kW nuclear reactor for the "SNAP 2" power system

a system will be mounted in a satellite nose cone for additional ground testing.

The first SNAP 2 reactor, designated the SNAP Experimental Reactor (SER), was not designed to be operated with a power conversion unit. It has completed a year's testing during which it generated 225,000kWh of heat, the equivalent of full time operation at design power for six months. The SER also logged the longest, uninterrupted operation of any known high-temperature nuclear reactor when it ran continuously for 1000 hours at design conditions of 1200 deg. Fah.

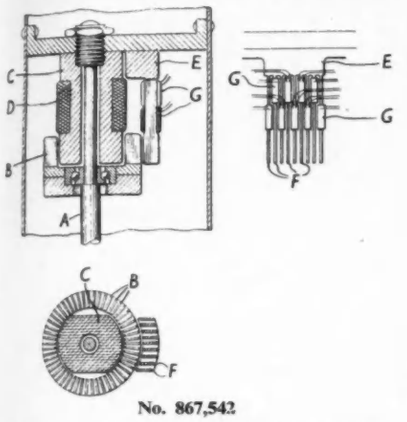
BRITISH PATENT SPECIFICATIONS

The dates printed are those of application and publication on completion. Copies of specifications may be obtained at the Patent Office Sales Branch, Southampton Buildings, Chancery Lane, W.C.2, 3s. 6d. each

MICROMETERS

867,542. March 6, 1958.—MICROMETER SCREW MEASURING MEANS, A.E.I.—John Thompson Nuclear Energy Company, Ltd., Crown House, Aldwych, London, W.C.2, George Herbert Shepherd, "Alvaston," Stockport Road West, Stockport, Cheshire and Donald Peter Stait, 61, Francis Way, Silver End, Witham, Essex.

This invention relates to micrometer screw gauges and has for an object to utilise digital counting techniques for indicating the degree of rotation of the micrometer screw. Referring to the drawing the



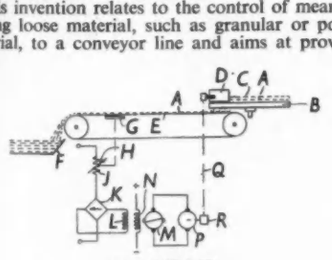
No. 867,542

spindle *A* rotatable in bearings is coupled to a toothed wheel *B*. A magnetic circuit provided comprises an annular element *C* concentric with the spindle and embraced by a coil *D* together with an element *E* which extends parallel to and on one side of the element *C*. The two elements are separated by an air gap in which the teeth of wheel *B* rotate. Element *E* includes a number of fingers such as *F* each having wound thereon a respective search coil *G*. The pitch relationship between fingers *F*, and the teeth of the wheel is slightly different from the pitch of the teeth on the wheel. An alternating current of some 4000 cycles per second applied to coil *D* causes a flux to circulate in the magnetic circuit. When a tooth is co-incident with a finger *F* it will complete a path of low magnetic reluctance and hence maximum flux will occur in that finger which will induce a voltage in coil *G* which can be indicated by a pulse counter of known form connected thereto. As the spindle is rotated a number of pulses will be obtained from coil *G*, the numerical magnitude of which will give an indication of the degree of rotation of the spindle. For a vernier indication the relative magnitude of the voltages induced in each of the upper and lower offset coils, will provide an indication of the intermediate position of a tooth between two fingers. The spindle to which the micrometer is coupled may be rotated by any convenient reversible, electrical, pneumatic or torsion spring means.—*May* 10, 1961.

ELECTRICAL ENGINEERING

867,865. December 5, 1956.—AUTOMATIC ELECTRIC CONTROL OF FEEDERS, Associated Electrical Industries, Ltd., 33, Grosvenor Place, London, S.W.1. (*Inventors: Donald Windsor Prowse and Raymond George Rayden.*)

This invention relates to the control of means for feeding loose material, such as granular or powder material, to a conveyor line and aims at providing

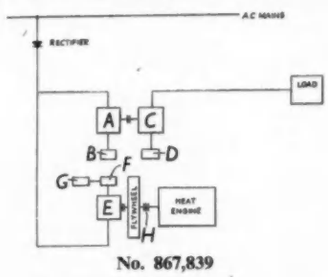


No. 867,865

an improved electric circuit arrangement for positioning a transfer member, such as a plough or blade, which is arranged to sweep the material from a rotating turntable to a conveyor. As can be seen from the drawing, loose material *A*, which is loaded on a turntable *B* to a height *C*, is swept by a plough or blade *D*, which forms the transfer member, to an endless conveyor band *E* which carries the material to a vat *F*. A beam *G* or other sensing member of a continuous weighing equipment which measures the weight of material carried per unit length of the band *E* is interconnected with a movable member *H* for instance a core, of a variable reactor *J*, supplied from an alternating current source. The output of the variable reactor serves to energise through a rectifier *K* a control field winding *L* of an amplidyne generator *M* which has a bias field winding *N* supplied from a direct current source to produce a magnetic field opposing the field produced by winding *L*. An electric motor *P* is supplied from the amplidyne generator *M* to position through interconnecting linkage means *Q* and a reduction gear *R* the transfer member *D*. The arrangement is such that when the actual rate of feeding corresponds to that required the signal supplied through the variable reactor excites the field winding *L* of the amplidyne to produce a field which is opposed to and cancels the field produced by the winding *N*, so that the amplidyne has zero output and the motor *P* supplied from the amplidyne will not rotate, and the member *D* will not be displaced. If the feeding rate differs from the required value the beam *G* moves, the impedance of the reactor *J* is changed, the field due to the signal supplied from the reactor to the field winding *L* is not cancelled by the field produced by winding *N*, and the amplidyne provides now an output suitable to rotate the motor to re-position the member *D*. This changes the weight of material per unit length of conveyor, the positions of the beam *G* and member *H*, and the energisation of the motor until the desired feeding rate is re-established, when the signals from the reactor will again cause zero amplidyne output and the member *D* will be at rest.—*May* 10, 1961.

867,839. March 1, 1957.—STAND-BY ELECTRIC GENERATORS, Blackstone and Co., Ltd., Stamford, Lincolnshire. (*Inventor: Gordon Edwin Cobb.*)

In general it is probably true that normal industrial usage of electricity is such that a limited depression in voltage and frequency can be accommodated in a transient period between mains failure and full takeover by a stand-by generator. However in certain instances, such as the telecommunication field, no depression at all can be tolerated if effective working is to be maintained. It is the object of the invention to provide a stand-by generator installation which is capable of fulfilling such conditions. Referring to the drawing, an alternating current load, for example a

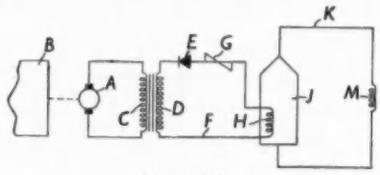


No. 867,839

load required by a telecommunication system where steady frequency is of paramount importance, is supplied by a d.c. motor *A* (having a starter *B*) driving an alternator *C* which incorporates an automatic voltage regulator *D*. The current for driving this d.c. motor is normally supplied from an a.c. mains source through a suitable rectifier as shown. A d.c. motor/generator machine *E* (having a starter *F*) is also normally powered through the rectifier from the mains, and this machine incorporates an automatic voltage output regulator *G*. This machine is normally run as a motor driving a high-inertia flywheel which is connectible through an automatic clutch *H* of known type to an internal combustion engine (normally a diesel engine), which is kept in readiness for starting. On failure of the a.c. mains supply the automatic clutch is operated to connect the flywheel to the engine and to start it. A certain speed drop is of course inevitable in the d.c. motor/generator machine *E* which, like the engine, is momentarily powered by the energy stored in the flywheel, but the characteristics of this machine and of the alternator supplying the load are such that their automatic voltage regulators *D* and *G* can compensate for this drop. As the engine takes up the load from the flywheel it drives the flywheel and motor/generator machine *E* to reinstate the d.c. power formerly derived through the mains rectifier and the a.c. current load is maintained throughout without frequency variation. When the a.c. mains power supply is restored, the engine is automatically declutched from the flywheel and motor/generator machine *E* and the d.c. motor *A* driving the alternator once more derives its power from the rectified current supplied through the rectifier.—*May* 10, 1961.

867,506. November 16, 1956.—BRAKE CONTROL SYSTEMS, Associated Electrical Industries, Ltd., 33, Grosvenor Place, London, S.W.1. (*Inventor: Adam Wawrzyniec Antoni Kwasnica.*)

This invention relates to brake control, and aims at providing a means for ensuring that the rate of deceleration provided by an electrically controlled brake, particularly of a kind exerting a mechanical braking effect, does not attain an undesirable value.



No. 867,506

One embodiment of the three described in the specification is shown in the drawing, wherein a tacho-generator *A* driven from a winder motor *B* is connected to the primary winding *C* of a transformer, so that the value of the voltage appearing across the secondary winding *D* of the transformer depends upon the rate of change of the voltage generated in the tacho-generator. Acceleration and deceleration of the motor cause rates of change in opposite senses and therefore currents in opposite directions whose discrimination is effected by a rectifier *E* arranged in the secondary circuit *F* of the transformer and poled to allow current to flow in this circuit only when the motor is decelerating. A non-linear resistor *G* is provided to maintain the current in the secondary circuit *F* at a non-effective value until the voltage reaches a predetermined value, at which the resistance value of resistor *G* decreases so that effective current is supplied to excite a control coil *H* of a magnetic amplifier *J* connected in the circuit *F*. The output circuit *K* of the amplifier *J* includes an operating coil *M* of a brake relay, the arrangement being such that energisation of this coil causes a reduction in braking torque. Where it is required to afford discrimination between acceleration and deceleration in both directions of rotation of a winder motor, the arrangement of the tacho-generator must be such that the polarity of the voltage generated by it does not change when the direction of winder movement changes. Alternatively the connections to the rectifier terminals can be arranged to change over when the direction of rotation of the winder motor and tacho-generator is reversed.—*May* 10, 1961.

METAL DRAWING

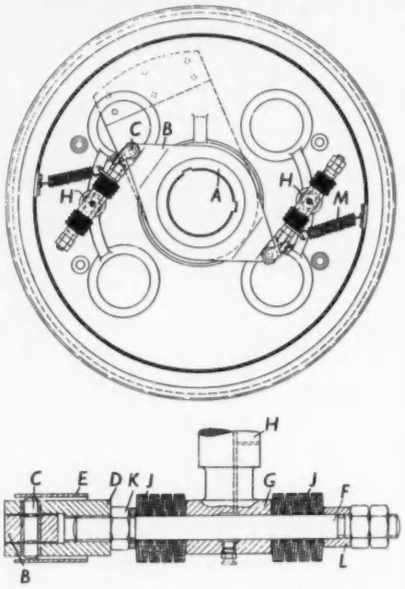
868,126. August 19, 1957.—DEEP DRAWING SHEET METAL, Farbwerke Hoechst Aktiengesellschaft vormals Meister Lucius and Brüning, Frankfurt (M)-Hochst, Germany.

This invention provides a process for deep drawing sheet metal, in which there is interposed as a non-adhering interlayer between the drawing die and the metal to be drawn a particular kind of foil of an artificial plastic. The interlayer is a hard foil of polyvinyl chloride free from plasticiser and having a K-value of 50 to 70, which foil, subsequently to its manufacture on a calender, is stabilised by a thermal after-treatment at a temperature of about 200 deg. Cent. to 220 deg. Cent., and preferably of 200 deg. Cent. The foil protects the drawing die and follows accurately the change in shape of metal during the drawing operation. The interlayer also leads to the production of a drawn product which is especially smooth and clean on its external surface covered by the interlayer during drawing, so that in many cases no after-treatment of the surface is necessary. Moreover, the use of such an interlayer has the unexpected result that it enables the depth of drawing in a single operation to be considerably greater than has been possible hitherto. Foils may be used that fall within the definition of hard foils given in DIN Specification No. 53371 printed in "Kunstoffe," 1954, page 210 (sheer modulus exceeding 5×10^8 kilograms per square centimetre). Suitable K-values are within the range of 50 to 70, and preferably in the range of 55 to 65.—*May* 17, 1961.

POWER TRANSMISSION

867,715. April 17, 1959.—PROTECTION AGAINST TORQUE OVERLOAD, Beteiligungs und Patentverwaltungsgesellschaft mit Beschranicter Haftung, Altendorfer Strasse 103, Essen, Germany.

One embodiment of the torque overload protection device is described in detail, by way of example, with reference to the accompanying drawing. A



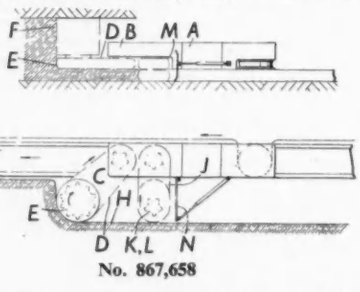
No. 867,715

V-pulley is rotatably mounted on a bush *A* keyed to a shaft. The bush has ears *B* containing sleeves which accommodate shear pins *C*. The outer ends of each shear pin are received in sleeves journalled in forked holding members *D*. The shear pins are prevented from dropping out of the members *D* by sliding sleeves *E*. A tie rod F screwed into each member is slidable in a sleeve *G* fixed to a bolt *H* rotatably mounted in the V-pulley. Plate springs *J* surrounding the tie rod are clamped between the nut *K* and sleeve *G* and this sleeve and an abutment sleeve *L*. An ear on each member *D* is connected by a tension spring *M* to the V-pulley. The driving torque of the pulley is transmitted through the bolts *H* and the springs *J* to the tie rods, to the members *D* and thence through the shear pins to the shaft. When a predetermined maximum torque is exceeded, the pins will shear at their weakened points and the shaft will cease to rotate. Continued rotation of the pulley causes the springs *M* to pull the members *D* and tie rods outwardly to rest positions in which the ears *B* are clear of the device.—*May* 10, 1961.

MINING MACHINES

867,658. January 11, 1960.—MACHINES FOR MINING COAL AND OTHER MINERALS, Mavor and Coulson, Ltd., 47, Redan Street, Glasgow, S.E. (*Inventor : George Jerrit.*)

The object of this invention is to provide a mining machine for effective haulage and guidance alongside the face of a seam and in use of which a substantial proportion of the coal won from the seam will be directly loaded upon a face conveyor by the cutting operation. The machine body comprises an electric



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motor *A* with a gearcase *B* at its leading end. The machine has a single leading jib *C* which supports and guides a cutter chain *D*. As usual, the jib can be swivelled about the vertical axis of its chain driving sprocket wheel. The arrangement is such that the loading stretch of the cutter chain travels inwards, as indicated by the arrow towards the body of the machine. At the free end of the jib the cutter chain travels round a sprocket wheel *E*, secured to a central shaft (not shown) which is journalled in bearings at the free end of the jib and which extends upwards. A superposed set of two or more cutter discs *F* are secured to and rotate with the shaft, The body of the machine rides upon the frame of a face conveyor *G* of the "armoured" type. The machine has in its base appropriate guiding supports, which slide upon the side members of the conveyor frame. That is to say, the machine body is directly upon and above the conveyor and the forward jib projects sidewise and forwards from the machine-conveyor combination. In operation of the machine, the cutter-chain-and-disc assembly works through the seam *H*, cutting the coal away and forming a new face. The assembly tends to wedge itself behind a buttock of coal, so that the inwards travelling picks act to burst the coal from the seam and push the lumps in advance of the gearcase. These lumps mainly fall directly upon the conveyor underneath the machine body and are conveyed forwards away from it. When the machine has reached the end of its travel, it can be flitted along the conveyor frame to the starting end of the workings—for which purpose the jib is swivelled from its working position into a temporary position directly above and in alignment with the conveyor. The machine, so far described, is a complete working unit, but it would leave a layer of coal on the floor of the mine. Accordingly, the machine preferably is equipped with means for cutting off this layer and loading the coal upon the conveyor. This cutting and loading means extends from the gearcase directly behind the jib and includes a jib *J* which has an under-slung auxiliary jib. At the free end of the jib structure there is journalled a vertical shaft (not shown) to which are secured two sprocket wheels *K*, *L* respectively associated with the main upper jib and the under-slung lower jib. A chain *M* adapted to receive loader flights is trained around the upper sprocket wheels and a comparatively short cutter chain is trained around the lower sprocket wheel *L* and a semi-circular guide at the inner end of the auxiliary jib. The arrangement is such that, in operation of the machine both chains are driven in unison, the lower chain cutting coal from the mine floor and the upper chain delivering to the conveyor whatever cut coal comes into the path of its flights. In association with the loader chain, immediately behind the jib structure is a back plate *N* supported by a strut which is adjustable in length. When the machine is being prepared for flitting, the jib structure *J* is detached and temporarily removed.—*May* 10, 1961.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS

To-day, June 2.—BRIGHTON, HOVE AND DISTRICT BRANCH : New Imperial Hotel, First Avenue, Hove, Sussex, Films, 7.30 p.m.

BRITISH INSTITUTION OF RADIO ENGINEERS

Wed. to Sun., July 5 *to* 9.—1961 Convention : Christ Church, The University, Oxford, "Radio Techniques and Space Research."

DRAWING OFFICE EQUIPMENT AND MATERIALS EXHIBITION

Mon. to Thurs., June 5 *to* 8.—Royal Horticultural Society's New Hall, Westminster, London, S.W.1, First National Exhibition.

INSTITUTE OF NAVIGATION

Wed., June 21.—Visit to National Maritime Museum, Greenwich, 2 p.m.

INSTITUTE OF PETROLEUM

Wed. to Sat., June 7 *to* 10.—Old Swan Hotel, Harrogate, Summer Meeting. Theme, "Information and its Dissemination."

INSTITUTE OF PHYSICS AND THE PHYSICAL SOCIETY

Fri., June 16.—APPLIED SPECTROSCOPY GROUP—MANCHESTER AND DISTRICT BRANCH : Literary and Philosophical Society Lecture Hall, George Street, Manchester, "Spectroscopic Studies Using Time Resolution Techniques," 10.30 a.m.

INSTITUTE OF SEWAGE PURIFICATION

Mon. to Fri., June 19 *to* 23.—Annual Conference at Brighton.

INSTITUTION OF CIVIL ENGINEERS

Tues., June 13.—Great George Street, Westminster, London, S.W.1, Annual General Meeting, 5.30 p.m.
Wed., June 21.—Great George Street, Westminster, London, S.W.1, Conversazione, 7.30 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS

Mon. to Fri., June 12 *to* 16.—ELECTRONICS AND MEASUREMENT SECTIONS : Savoy Place, London, W.C.2, International Conference on "Components and Materials used in Electronic Engineering."
Tues. to Thurs., June 20 *to* 22.—SOUTH MIDLAND CENTRE : Diamond Jubilee Celebrations with visits to the North Staffs Sub-Centre, Rugby Sub-Centre and to the Main Centre in Birmingham.

INSTITUTION OF MECHANICAL ENGINEERS

Wed., June 7.—SOUTHERN BRANCH : Visit to Pulsometer Engineering Company, Ltd., Oxford Road, Reading, 2.20 p.m.
Sat., June 10.—LONDON, EASTERN AND SOUTHERN GRADUATES' SECTIONS : 1, Birdcage Walk, Westminster, London, S.W.1, Joint Summer Meeting.
Wed., June 14.—EAST MIDLANDS GRADUATES' SECTION : Visit to Jaguar Cars, Ltd., Coventry, 2 p.m.
Sat., June 17.—SOUTHERN BRANCH : Visit to Godstone Pumping Station, Mid-Kent Water Company, Canterbury, 10.30 a.m.
Sat., June 24.—SOUTHERN BRANCH : Visit to Brighton Corporation Water Department, Church Street, Brighton, and to Hills Oak Pumping Station, 2.15 p.m.

INSTITUTION OF PLANT ENGINEERS

Tues., June 6.—LONDON BRANCH : Royal Society of Arts, John Adam Street, London, W.C.2, "Telecommunications," S. Welch, 6.30 p.m.

INSTITUTION OF PRODUCTION ENGINEERS

Wed., June 14.—1961 Viscount Nuffield Paper; Large Lecture Theatre, Engineering Faculty, The University, Bristol, "Some Aspects of Engineering Progress," Sir Willis Jackson, 6.30 p.m.

INSTITUTION OF PUBLIC HEALTH ENGINEERS

Fri., June 9.—SUMMER MEETING : Caxton Hall, London, S.W.1, Annual General Meeting, 4.30 p.m. and "The Development of Bracknell New Town with particular reference to its Effect on Local Government Administration," H. Charlesworth, 6 p.m.
Sat., June 10.—Visit to Bracknell New Town and recently completed works of special interest.

JOINT COMMITTEE ON STRUCTURAL CONCRETE

To-day, June 2.—Royal Commonwealth Society, Craven Street, London, W.C.2, "The Bridges of the Autostrada Del Sole," Dr. Ing. Sergio de Amicis, 6 p.m.

PLASTICS INSTITUTE

Mon. and Tues., June 19 *and* 20.—Institution of Electrical Engineers, Savoy Place, London, W.C.2, Conference on "Education and Training in the Plastics Industry."

ROYAL AERONAUTICAL SOCIETY

To-day, June 2.—ROTORCRAFT SECTION : Lecture Theatre, 4, Hamilton Place, London, W.1, "Development of Stabilising Equipment of Helicopters," P. D. Macmahon, 6 p.m.

ROYAL SOCIETY

Thurs., June 8.—Burlington House, Piccadilly, London, W.1, "The Rapid Measurement of Intensity with an Oscillating Fabey-Perot Spectrometer : Isotope Abundance in Mercury," D. J. Bradley, and "Precise Measurements of the Density of Mercury at 20 deg. Cent., II. Content Method," A. H. Cook, 4.30 p.m.

WOMEN'S ENGINEERING SOCIETY

Wed., June 14.—"Hope House," 45, Great Peter Street, Westminster, London, S.W.1, Annual General Meeting, 7 p.m.

Advanced Engineering Courses

Post-Graduate Course in Engineering Production. THE UNIVERSITY OF BIRMINGHAM, Edgbaston, Birmingham, 15. The primary object of this post-graduate course of studies, which occupies one academic year, is to provide advanced education and training for production engineering and management positions in industry. Graduates of Birmingham and other Universities, with degrees in science subjects and with satisfactory industrial experience, and other students with equivalent qualifications, are eligible for admission. A systematic course of studies on the principles of engineering production and on industrial management subjects is provided together with suitable practical work in the form of special research projects and case studies in industry. Application for admission to the course commencing each October should be made to the Registrar not later than July 30. Fee £95.

Post-Graduate Course in Operational Research and Allied Studies. THE UNIVERSITY OF BIRMINGHAM, Edgbaston, Birmingham, 15. The object of this post-graduate course of studies, which occupies one academic year, is to provide advanced education and training for graduates who intend to take up careers in operational research in industry. Graduates of Birmingham and other Universities with first or second class honours degrees in science, mathematics or economics (with statistics) and some industrial experience are eligible for admission. A systematic course of studies is offered, leading to examinations in six subjects. In addition, each student is required to undertake an investigation of a practical industrial problem and to submit a report for examination. Application for admission to the course commencing each October should be made to the Registrar not later than July 30. Fee £95.

Welding Technology. THE COLLEGE OF AERONAUTICS, Cranfield, Bletchley, Bucks. A one-year post-graduate course which will take place during the Autumn, Spring and Summer terms of the academic year 1961–62. Autumn term commences on October 9. The purpose of the course, which has been sponsored by the Institute of Welding and the British Welding Research Association, is to provide students of graduate status in either metallurgy or engineering with a specialised training to fit them for posts in the design, development and production departments of the many industries where welding is now vital. A range of subjects will be covered with a particular concentration on the special metallurgical considerations inherent in welding ; the welding processes, their characteristics and fields of application, and design for welding and the essential production techniques. Fees : British students £75 ; Commonwealth students £250 ; foreign students £350. Residence £126 10s.

Road Materials and Construction. ROAD RESEARCH LABORATORY, Harmondsworth. Courses will be held as follows : "Concrete," No. 33C, September 26 to October 5 ; No. 34C, October 10 to 19 ; "Bituminous (including tar) Materials," No. 33B, October 24 to November 3 ; No. 34B, November 7 to 17 ; "Soil Mechanics," No. 33A, November 21 to 28 ; No. 34A, December 5 to 12 ; "Tropical Roads," No. 5T, November 29 to December 1 ; No. 6T, December 13 to 15. The two latter courses will follow immediately after courses 33A and 34A respectively, and members of those courses may attend without further charge. The fee for each course is £12 12s.

The Tools of Engineering Research. NOTTINGHAM AND DISTRICT TECHNICAL COLLEGE, Burton Street, Nottingham. A course designed to appeal to full-time research workers and to lecturers engaged in research into mechanical engineering problems. The course runs from Monday to Friday, June 5 to 16. Fee £6 6s.

Time-Series Analysis. THE UNIVERSITY OF BIRMINGHAM, Institute for Engineering Production, "Southfield," 16, Norfolk Road, Edgbaston, Birmingham, 15. The course is concerned with the theory and practice of the analysis of time-series, and is intended to serve as an introduction to the subject for those who are concerned with the analysis of production processes, in order to encourage them to apply these modern techniques to the solution of plant problems. The course will be held from 9.30 a.m., Monday, July 10, until 3.30 p.m., Friday, July 14. Fee thirty-five guineas, covering course papers and all incidental charges and meals.